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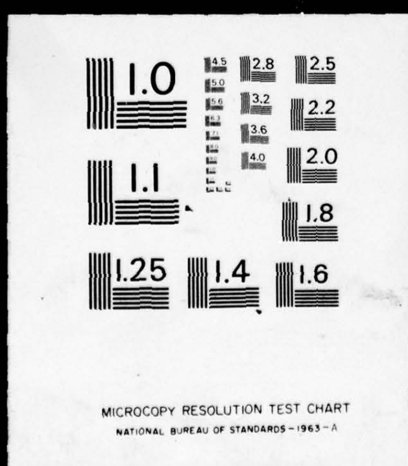

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LASH AMPHIBIOUS POST-ASSAULT SUPPORT (LAPS) MISSION

PHASE I - CONCEPTUAL DESIGN ANALYSIS

Sponsored By

NAVAL FACILITIES ENGINEERING COMMAND

Prepared For

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
Mobile Support Systems Group
Annapolis, Maryland 21402

Contract No. N00600-72-D-0308
Task No. FD75

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1 March 1976

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The Conceptual Design Analysis of the LASH Amphibious Post Assault Support (LAPS) Mission is a study to determine the feasibility of utilizing the LASH vessel as a self-sustaining support vessel to transport the large components and equipment needed to implement Over-the-Shore Discharge of containership (OSDOC) resupply of an amphibious operation. This study goes into considerable detail evaluating different lifting technique such as lifting beams employed with a 2-point lift lifting beam. → next page

cont

20. (Cont'd) with counterweights and compression members, cantilever lift frames, and external lift methods, all requiring different kinds of lifting hardware. Each item of outsize cargo is considered in exploring each lifting technique and calculations are included showing the practicality of each component lift compared to crane and hardware capability as well as trim and stability considerations of the component when discharged in an open sea.

Conclusions as to the most viable lifting technique to be developed further are based on the following considerations: extent of modification, lift capability, intraship mobility, ship down time, cost and yard facility requirements.

On this basis, the cantilever lift frame is the technique recommended for further development comprising Phase II of the LAPS Program.

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ABSTRACT

Phase I - Conceptual Design Analysis of the LASH Amphibious Post Assault Support (LAPS) Mission is a study to determine the feasibility of utilizing the LASH vessel as a self-sustaining support vessel to transport the large components and equipment needed to implement OSDOC[1] resupply of an amphibious operation.

The LASH System[2] employs highly sophisticated high speed ships capable of loading, stowing and off-loading lighter barges in an open sea. The barges are approximately 61'-6" x 31' x 13' high and may have a gross weight of 500 short tons. Lifting the barges is accomplished by a lighter gantry crane utilizing four lifting sockets attached to the corner lighter posts. Movement fore and aft and positioning of the cargo over the holds is facilitated by the traveling gantry. Although the LASH lighter crane has a high capability and reliability factor desirable for military application, the crane configuration is not well suited for handling outsize cargo components, since the fore and aft space in the stern well is only 32 feet and the pontoon causeway components measure 92 feet.

This study goes into considerable detail evaluating different lifting techniques such as lifting beams employed with a 2-point lift, lifting beams with counterweights and compression members, cantilever lift frames, and external lift methods, all requiring different kinds of lifting hardware. Each item of outsize cargo is considered in exploring each lifting technique and calculations are included showing the practicality of each component lift compared to crane and

(1) Over-the-Shore Discharge of Containership
(2) Developed by Mr. Jerome Goldman, Pres. of Friede & Goldman, Inc.

ABSTRACT (Continued)

hardware capability as well as trim and stability considerations of the component when discharged in an open sea.

Conclusions as to the most viable lifting technique to be developed further are based on the following considerations: extent of modification, lift capability, intraship mobility, ship down time, cost and yard facility requirements.

On this basis, the cantilever lift frame is the technique recommended for further development comprising Phase II of the LAPS Program.

LASH AMPHIBIOUS POST-ASSAULT SUPPORT (LAPS) MISSION

PHASE I - CONCEPTUAL DESIGN ANALYSIS

1. INTRODUCTION

This study compiles a list of the principal characteristics of the LASH Ships and evaluates lifting concepts for loading and off-loading outsize components to determine the feasibility of utilizing the LASH vessels in the LASH Amphibious Post-Assault Support (LAPS) Mission.

The principal characteristics of the (20) U. S. Flag LASH Ships, are tabulated with particular emphasis on those parameters which might affect the lifting, stowing and transfer of Navy/USMC outsize cargo, particularly the elevated causeway components. This evaluation takes into account the facts; that there are the short (C-8) and long (C-9) classes of LASH Ships, that there are two types of lighter gantry cranes (Alliance and Morgan), and that the vessels were manufactured for five different operators (Prudential Grace Lines, Pacific Far East Line, Delta Steamship Lines, Waterman Steamship Corp., and Central Gulf Steamship Corp.)

Calculations were performed for each of the several outsize cargo components considering both the Morgan and Alliance Cranes based on both two and four point lifting configurations. Results of the calculations are summarized to determine the most viable lifting subsystem consistent with availability and acquisitional cost.

In addition, the bearing loads for each cargo component were calculated and are compatible with the LASH deck strength members. A typical stowage

configuration of components is illustrated in Figure 7.1 by a three dimensional sketch, showing the LASH outboard profile with identification of the components loaded.

2. COMPARISON OF LASH SHIP CHARACTERISTICS

Eleven of the twenty U. S. Flag LASH Ships are C-8's and they are owned and operated by Prudential Grace Lines and the Pacific Far East Line. All of the C-8 LASH Ships are fitted with the Alliance Lighter Gantry Crane. Nine of the LASH Ships are the larger C-9's and they are owned and operated by three different companies, namely; the Delta Steamship Lines, Waterman Steamship Corp. and Central Gulf Steamship Corp. The Delta and Central Ships are outfitted with the Morgan Lighter Crane; the three Waterman Ships have Alliance Cranes. All of the (9) C-9 Ships have had the circuitry of the lighter cranes changed as a National Defense Feature (NDF) to permit the lifting of off-center loads by means of a 2-point lift using the two aft lighter lifting sockets. In addition, the cranes can move somewhat farther aft permitting approximately 32' of fore and aft clearance in the stern lifting well. That is, it is approximately 32' between the centerline of the aft lighter frame lifting sockets and the transom of the ship.

Allowing one foot of clearance between the forward extremity of the outsize cargo component and the LASH transom, there is an actual distance of 31'-9" from the forward component extremity to the centerline of the after lifting sockets of the LASH lighter lifting frame. This dimension shall be employed in subsequent calculations.

An LCM-8 lifting beam was designed and three units were fabricated as a National Defense Feature. The LCM-8 lifting beam was designed to be mated to the aft two lifting sockets of either the Morgan or Alliance lighter crane lifting frames. The LCM-8 lift beam was intended to permit loading LCM-8 landing craft aboard C-9 LASH Ships as outsize deck cargo. The three LCM-8 beams have

been certified by the American Bureau of Shipping (ABS). Certification is based on the capacity of the Alliance Crane, 416.6 Kips[1] symmetrical load or an eccentric load of 208.3 Kips at either end.[2] All calculations herein are based on the Alliance Crane limits.

Principal characteristics of the C-8 Ships that are operated by Prudential Grace Lines and the Pacific Far East Line are quite similar and are shown on LASH Outboard Profile Figure 2.1. The three C-9 Ships operated by Delta differ somewhat from the other C-9 Ships because of their container capability and are shown on LASH Outboard Profile Figure 2.2 The other C-9 Ships operated by Waterman and Central Gulf (3 each company) have only lighter capability and are shown on LASH Outboard Profile Figure 2.3. Figure 2.4 is a plan view of a LASH Ship. The principal difference between the C-8 and C-9 LASH Ships is an additional hold for the C-9 just forward of the stackhouses. For information as to hold configurations for the C-8 and C-9 LASH Ships, refer to Figures 2.5 and 2.6.

More detailed LASH principal characteristics that could measurably affect the application of LASH Ships to the LAPS Mission, are shown in Table 2.1, Principal Characteristics of U. S. Flag LASH Ships.

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(1) Kips - 1 Kip = 1000 pounds.
(2) The beams were designed for the limits of the Morgan Crane; i.e., 448 Kip symmetrical load or 302.4 Kip eccentric load.

TABLE 2.1 PRINCIPAL CHARACTERISTICS OF U. S. FLAG LASH SHIPS

Item	Characteristic	Prudential Grace Lines	Pacific Far East Line	Delta Steamship Lines	Waterman Steamship Corp.	Central Gulf Steamship Corp.
1	MARAD Design	C8-5-81b	C8-S-81b	C9-S-81d	C9-S-81d	C9-S-81d
2	Hull Numbers (MARAD)	228 229 230 236 237	231 232 233 234 235 238	259 260 261	262 263 264	265 274 275
3	Ship Names	LASH ITALIA LASH TURKIYE LASH ESPANA LASH ATLANTICO LASH PACIFICO	THOMAS E. CUFFE GOLDEN BEAR PACIFIC BEAR JAPAN BEAR CHINA BEAR PHILLIPPINE BEAR	DELTA MAR DELTA NORTE DELTA SUD	ROBERT E. LEE STONEWALL JACKSON SAM HOUSTON	GREEN VALLEY GREEN HARBOR GREEN ISLAND
4	Length overall including overhang	820'-0"	820'-0"	893'-4"	893'-4"	893'-4"
5	Length overall excluding crane overhang	772'-0"	772'-0"	845'-4"	845'-4"	845'-4"
6	Length between perpendiculars	724'-0"	724'-0"	797'-4"	797'-4"	797'-4"
7	Molded Breadth (Beam)	100'-0"	100'-0"	100'-0"	100'-0"	100'-0"
8	Depth (Molded) at the side	60'-0"	60'-0"	60'-0"	60'-0"	60'-0"
9	Shaft Horsepower (ABS Max.)	32,000	32,000	32,000	32,000	32,000
10	Speed, Normal @ 28' W.L.	22.5 Knots	22.5 Knots	22 Knots	22 Knots	22 Knots
11	Draft, Design	28'-0"	28'-0"	28'-0"	28'-0"	28'-0"
12	Deadweight Tonnage @ 28' W.L.	17,990 L.T.	17,904 L.T.	21,552 L.T.	21,901 L.T.	21,901 L.T.
13	Full Load Draft	35'-1-1/4"	35'-1-3/16"	38'-1-1/2"	38'-1-1/2"	38'-1-1/2"
14	Deadweight Tonnage @ Full Load Draft	29,820 L.T.	29,749 L.T.	40,592 L.T.	40,679 L.T.	46,153 L.T.
15	U. S. Gross Tonnage	26,406	26,456	32,269	32,269	32,269
16	U. S. Net Tonnage	18,706	18,706	24,767	24,767	24,767
17	Displacement (Design)	32,761 L.T.	32,700 L.T.	38,062 L.T.	38,062 L.T.	38,062 L.T.
18	Displacement Maximum Draft	44,606 L.T.	44,606 L.T.	57,082 L.T.	57,082 L.T.	56,451 L.T.
19	Light Ship Displacement	14,786 L.T.	14,857 L.T.	16,510 L.T.	16,162 L.T.	16,161 L.T.

TABLE 2.1 PRINCIPAL CHARACTERISTICS OF U. S. FLAG LASH SHIPS (Continued)

Item	Characteristic	Prudential Grace Lines	Pacific Far East Line	Delta Steamship Lines	Waterman Steamship Corp.	Central Gulf Steamship Corp.
20	Length on 28'-0" Waterline	740'-0"	740'-0"	813'-4"	813'-4"	813'-4"
21	Length @ Scantling Draft			815'-2"	815'-2"	815'-2"
22	Scantling Length			790'-8-9/16"	790'-8-9/16"	790'-8-9/16"
23	Scantling Draft	35'-0"	35'-0"	38'-0"	38'-0"	38'-0"
24	Depth @ Main Deck Molded - Centerline	61'-0"	61'-0"	61'-0"	61'-0"	61'-0"
25	Light Ship Draft	15'-3-1/8"	15'-3-5/8"	14'-6-1/4"	14'-3-3/8"	14'-3-3/8"
26	Length Overall including crane overhang	820'-0"	820'-0"	893'-4"	893'-4"	893'-4"
27	Speed - Maximum Draft	19.1 Knots	19.1 Knots	19.1 Knots	19.1 Knots	19.1 Knots
28	Accommodations	40	45	45	38	35
29	Lifeboats - Diesel	(1) 50 Persons	(1) 50 Persons	(1) 48 Persons	(1) 45 Persons	(1) 35 Persons
30	Lifeboats - Hand Powered	(1) 50 Persons	(1) 50 Persons	(1) 48 Persons	(1) 45 Persons	(1) 35 Persons
31	Davits - Gravity Type	2	2	2	2	2
32	Fuel	5,344 L.T.	5,344 L.T.	5,740 L.T.	5,740 L.T.	5,740 L.T.
33	Liquid Cargo	1,164 L.T.	1,164 L.T.	None	None	None
34	Cargo and Ballast Tanks			389,093 cu.ft.	389,093 cu.ft.	389,093 cu.ft.
35	Diesel Oil	112.72 L.T.	112.72 L.T.	114.04 L.T.	112.7 L.T.	112.7 L.T.
36	Lube Oil	67.65 L.T.	76.86 L.T.	85.73 L.T.	76.5 L.T.	76.5 L.T.
37	Salt Water Ballast	16,063 L.T.	16,063 L.T.	10,174 L.T.	8,808 L.T.	8,808 L.T.
38	Passive Stabilizer Tanks	1,679.45 L.T.	1,679.45 L.T.	1,682.58 L.T.	1,682.6 L.T.	1,682.6 L.T.
39	Fresh Water Tanks	792.58 L.T.	792.58 L.T.	853.18 L.T.	853.18 L.T.	853.18 L.T.
40	Main Propulsion	Steam	Steam	Steam	Steam	Steam
41	Endurance (Nautical Miles)	15,000	15,000	15,000	15,000	15,000
42	Number of Propellers	One	One	One	One	One
43	Evaporator Capacity - Gallons/Day	25,000	25,000	25,000	25,000	25,000

TABLE 2.1 PRINCIPAL CHARACTERISTICS OF U. S. FLAG LASH SHIPS (Continued)

Item	Characteristic	Prudential Grace Lines	Pacific Far East Line	Delta Steamship Lines	Waterman Steamship Corp.	Central Gulf Steamship Corp.
44	Steering Gear - Elect. Hyd. (2) 75 H.P. Motors	Sperry Rand	Sperry Rand	Avondale	Avondale	Avondale
45	Refrigeration - Containerized	3 Tons	3 Tons	3 Tons	3 Tons	3 Tons
46	Air Conditioning	(2) 40 Ton Units	(2) 40 Ton Units	(2) 45 Ton Units	(2) 45 Ton Units	(2) 45 Ton Units
47	Generator Capacity - Ships Service T.G.	2,500 KW	2,500 KW	2,000 KW	2,000 KW	2,000 KW
48	Generator Capacity - Aux. Diesel	2,000 KW	2,000 KW	2,000 KW	2,000 KW	2,000 KW
49	Generator Capacity - Emerg. Diesel	250 KW	250 KW	250 KW	250 KW	250 KW
50	Generator Load Analysis					
	Maximum Sea Load	2,201 KW	2,201 KW	2,214 KW	1,850 KW	1,820 KW
	Maximum Port Load	1,600 KW	1,600 KW	3,020 KW	1,206 KW	2,326 KW
	Deck Machinery included (Sea)	40 KW	40 KW	55 KW	40 KW	40 KW
51	Emergency Generator Load Analysis					
	Maximum Sea Load	246 KW	246 KW	242 KW	242 KW	242 KW
	Maximum Port Load	134 KW	134 KW	138 KW	138 KW	138 KW
52	Number of Cargo Holds	6	6	7	7	7
53	Cargo Holds arranged to carry lighters only, access in wing walls, using wing tanks for grain or ballast.	Containers Fwd.	Containers Fwd.	Containers Fwd.	Lighters Only	Lighters Only
54	Barge Size - Length	61'-6"	61'-6"	61'-6"	61'-6"	61'-6"
	Barge Size - Width	31'-2"	31'-2"	31'-2"	31'-2"	31'-2"
	Barge Size - Height	13'-0"	13'-0"	13'-0"	13'-0"	13'-0"
55	Barge Weight	80 L.T.	80 L.T.	80 L.T.	80 L.T.	80 L.T.
56	Dry Cargo - No. of Lighters	49	49	55	89	89
	Grain Capacity					
	Below Deck	712,800 cu.ft.	712,800 cu.ft.	1,023,100 cu.ft.	1,065,300 cu.ft.	1,065,300 cu.ft.
	On Main Deck at Centerline	39,600 cu.ft.	39,600 cu.ft.	80,400 cu.ft.	80,400 cu.ft.	80,400 cu.ft.
	On Hatch Covers	217,800 cu.ft.	217,800 cu.ft.	603,000 cu.ft.	643,200 cu.ft.	643,200 cu.ft.
	Bale Capacity					
	Below Deck	702,000 cu.ft.	702,000 cu.ft.	999,600 cu.ft.	1,038,800 cu.ft.	1,038,800 cu.ft.
	On Main Deck at Centerline	39,000 cu.ft.	39,000 cu.ft.	78,400 cu.ft.	78,400 cu.ft.	78,400 cu.ft.
	On Hatch Covers	214,500 cu.ft.	214,500 cu.ft.	588,000 cu.ft.	627,200 cu.ft.	627,200 cu.ft.
	NOTE: Second tier of lighters restricted to a maximum of 380 L.T. due to stowage of container lift frame above hatch.					

TABLE 2.1 PRINCIPAL CHARACTERISTICS OF U. S. FLAG LASH SHIPS (Continued)

Item	Characteristic	Prudential Grace Lines	Pacific Far East Line	Delta Steamship Lines	Waterman Steamship Corp.	Central Gulf Steamship Corp.
57	Alternate Lighters	12	12	None	None	None
	Grain Capacity	237,600 cu.ft.	237,600 cu.ft.	None	None	None
	Bale Capacity	234,000 cu.ft.	234,000 cu.ft.	None	None	None
58	Containers	250	334	144	None	None
	Bale Capacity	350,700 cu.ft.	350,700 cu.ft.	151,200 cu.ft.	None	None
59	Alternate Number of Containers	720	720	None	None	None
	Bale Capacity	757,000 cu.ft.	757,000 cu.ft.	None	None	None
60	Lighter Gantry Crane (Capacity)	500 S.T.	500 S.T.	510 S.T.	500 S.T.	510 S.T.
61	Lighter Gantry Crane (Builder)	Alliance	Alliance	Morgan	Alliance	Morgan
62	Container Gantry Crane (Builder)	Paceco	Paceco	Skagit	None	None
63	Capacity of Container Crane	30 L.T.	30 L.T.	30 L.T.	None	None
64	Maximum Lift Position of Lighter Gantry Crane	96'-0" A.B.L.	96'-0" A.B.L.			
65	30 Ton Container Crane secured over Hatch #1 - Frames 52 - 58. Outsize cargo cannot be carried forward of Frame 60	Yes	Yes	Yes	No Container Crane	No Container Crane
66	Lighter Handling - Portable LCM Guide Rails	No	No	Yes	Yes	Yes
67	Tiedown to suit 500 Ton Gantry	Suitable	Suitable	Suitable	Suitable	Suitable
68	Constant Tension Mooring Winches	(8) @ 150,000#		(4) @ 150,000# pull	(4) @ 150,000# pull	(4) @ 150,000# pull
69	Barge Handling Winches - Stern Well	2	2			
70	Retrieving Winches Aft - Stern Well	2	2			
71	Mooring Winches Aft - Stern Well	2	2			
72	LASH Gantry Crane - Manufacturer	Alliance	Alliance	Morgan	Alliance	Morgan
	Gantry Motors	(4) @ 150 H.P.	(4) @ 150 H.P.	(4) @ 150 H.P.	(4) @ 150 H.P.	(4) @ 150 H.P.
	Hoist Motors	(4) @ 150 H.P.	(4) @ 150 H.P.	(4) @ 150 H.P.	(4) @ 150 H.P.	(4) @ 150 H.P.
73	Lighter load frame tie down arrangement			(for Morgan Crane)		(for Morgan Crane)
74	Light Weight Snug Stowing Anchors	(2) @ 22,470 lbs.	(2) @ 22,470 lbs.	(2) @ 22,470 lbs.	(2) @ 22,470 lbs.	(2) @ 22,470 lbs.
75	Spare Anchor	(1) @ 19,110 lbs.	(1) @ 19,110 lbs.	(1) @ 19,110 lbs.	(1) @ 19,110 lbs.	(1) @ 19,110 lbs.

TABLE 2.1 PRINCIPAL CHARACTERISTICS OF U. S. FLAG LASH SHIPS (Continued)

Item	Characteristic	Prudential Grace Lines	Pacific Far East Line	Delta Steamship Lines	Waterman Steamship Corp.	Central Gulf Steamship Corp.
76	Capstans Aft For Handling Outsize Cargo Barge Handling Hawse Pipe	 2 Aft 2 Aft	 2 Aft	 2 Aft	 2 Aft 2 Aft	 2 Aft
77	Mooring Winch Lines	2 Aft	2 Aft		(4) 150,000 lbs.	(4) 150,000 lbs.
78	Container Crane Tie Down - P & S	Fr. 60-1/2	Fr. 60-1/2	Fr, 60-1/2	None	None
79	Removal of Container Guides - Holds 1B & 1C	Yes	Yes	Yes	None	None
80	Maximum Deck Loadings (Double Bottom) Hatch 2b - Frame 74 Hatch 3b - Frame 82 Hatch 4b - Frame 90 Hatch 5a - Frame 105 Hatch 6b - Frame 112 Hatch 7b - Frame 129		 2,900 lb./ft.^{2} 2,900 lb./ft.^{2} 900 lb./ft.^{2} 2,200 lb./ft.^{2} 2,100 lb./ft.^{2} None	 2,900 lb./ft.^{2} 2,900 lb./ft.^{2} 2,900 lb./ft.^{2}	 2,900 lb./ft.^{2} 2,900 lb./ft.^{2} 2,900 lb./ft.^{2} 900 lb./ft.^{2} 2,200 lb./ft.^{2} 2,100 lb./ft.^{2}	
81	Maximum Deck Loadings Hatch 1a Hatch 1b Hatch 1c Hatch 2b Hatch 3b Hatch 4 Hatch 5 Hatch 6	 1,500 lb./ft.^{2} 1,500 lb./ft.^{2} 2,900 lb./ft.^{2} 2,900 lb./ft.^{2} 2,900 lb./ft.^{2} 900 lb./ft.^{2} 2,200 lb./ft.^{2} 2,100 lb./ft.^{2}				
82	Lighters are secured by lashing to padeyes welded to the box girder or hatch coaming. Same detail applicable to tie down of out-size cargo.	Suitable	Suitable	Suitable	Suitable	Suitable
83	Container Deck Sockets	Hatches 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, and 3c	Hatches 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, and 3c	Hatches 1a, 1b, and 1c	None	None
84	Lighter and Container Crane Cable Trays on Wing Walls - No Interference	Suitable	Suitable	Suitable	Suitable	Suitable
85	Containers carried forward Frames 52 - 67 and on the wing walls aft. Lighters are carried only one high aft of Frame 67.	Yes			No	No

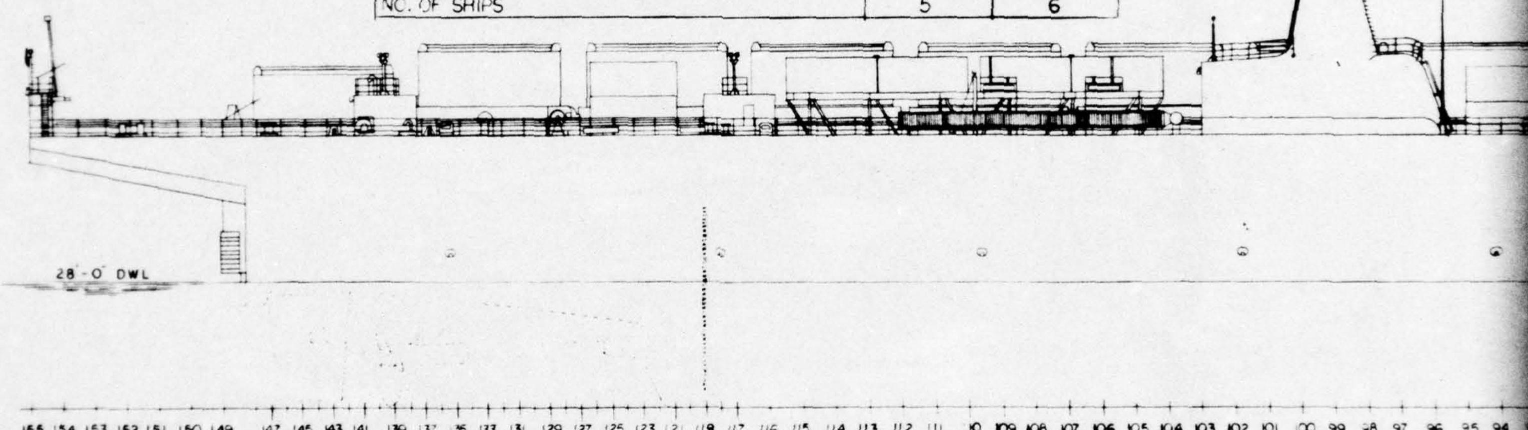
TABLE 2.1 PRINCIPAL CHARACTERISTICS OF U. S. FLAG LASH SHIPS (Continued)

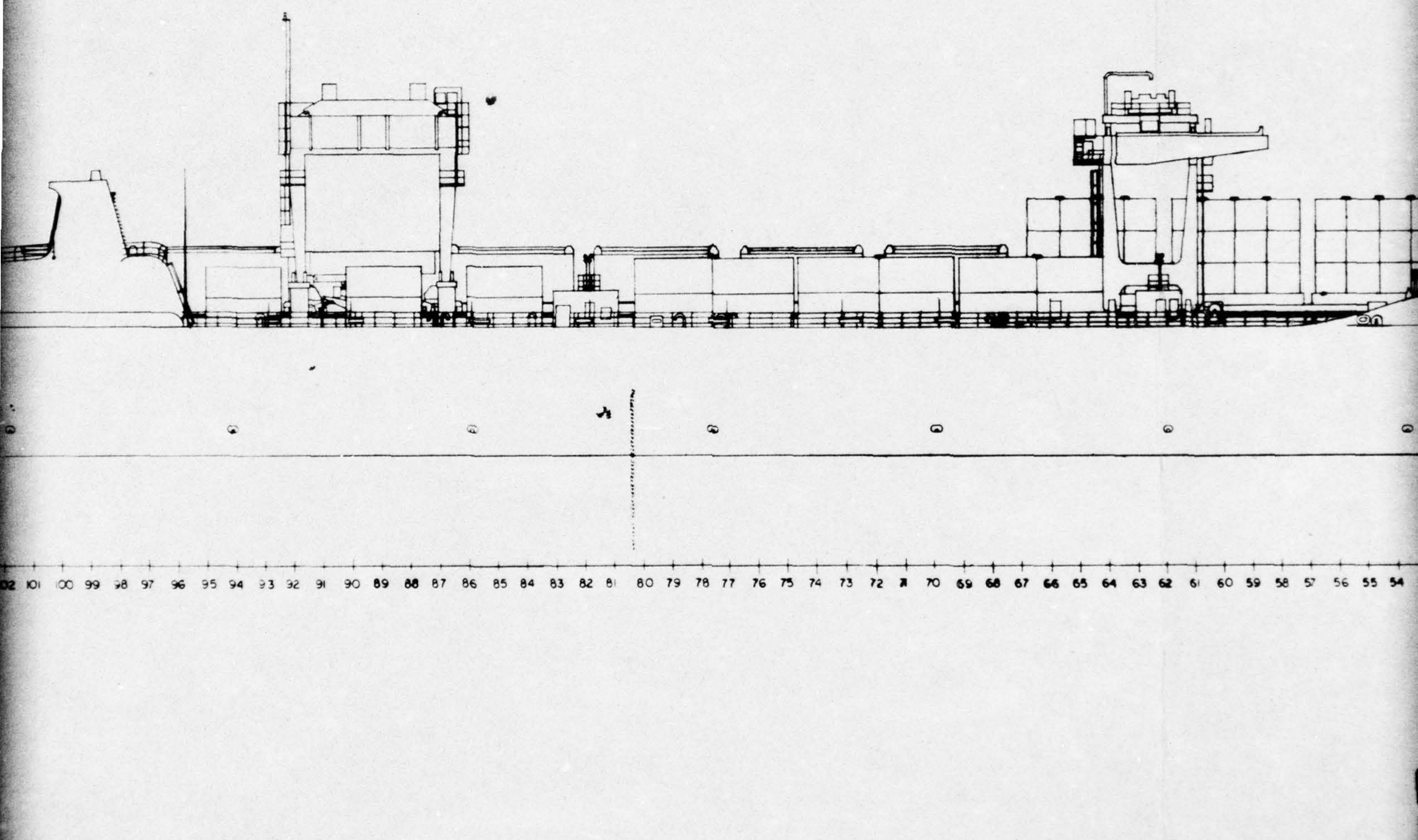
Item	Characteristic	Prudential Grace Lines	Pacific Far East Line	Delta Steamship Lines	Waterman Steamship Corp.	Central Gulf Steamship Corp.
86	General Arrangement Main Deck - Fitted with tension mooring winches, stowage lockers and gantry tie downs on wing walls - No interference	Yes		Yes	Yes	Yes
87	Maximum S. W. Bending Moment	377,669 ft. tons	377,669 ft. tons	538,555 ft. tons	538,555 ft. tons	538,555 ft. tons
88	Deck Plating and Framing Aft - Adequate for outsize cargo deck loading.	Yes	Yes	Yes	Yes	Yes
89	Firemain Stations on Main Deck Wing Walls Aft of Frame 52 - No Interference.	Yes	Yes	Yes	Yes	Yes
90	Miscellaneous Longitudinal Bulkheads Aft	Suitable	Suitable	Suitable	Suitable	Suitable
91	W. T. Longitudinal Bulkheads - 35' and 40' off Centerline Aft - Adequate for outsize deck cargo.	Yes	Yes	Yes	Yes	Yes
92	I. B. Plating in way of holds is designed for the carriage of lighters.	Yes	Yes	Yes	Yes	Yes
93	Top plating in the way of Hold #1 stiffened for the carriage of containers.	Yes	Yes	Yes	No	No
94	Fire Stations on Wing Walls - No Interference.	Yes	Yes	Yes	Yes	Yes
95	Location of Exhaust Fans on Wing Walls - No Interference.	10	10	10	10	6
96	Plumbing and Deck Drains - No Interference	Suitable	Suitable	Suitable	Suitable	Suitable
97	Intake Fans on Wing Walls - No Interference	2	2	2	2	2
98	Craneway Extension Aft	48'-0"	48'-0"	48'-0"	48'-0"	48'-0"
99	Fire Control Plan - No Interference	Suitable	Suitable	Suitable	Suitable	Suitable

TABLE 2.1 PRINCIPAL CHARACTERISTICS OF U. S. FLAG LASH SHIPS (Continued)

Item	Characteristic	Prudential Grace Lines	Pacific Far East Line	Delta Steamship Lines	Waterman Steamship Corp.	Central Gulf Steamship Corp.
100	Access in Box Girders - No Interference	Suitable	Suitable	Suitable	Suitable	Suitable
101	Access and Stowages in Wing Walls - No Interference	Suitable	Suitable	Suitable	Suitable	Suitable
102	32' and 40' Levels, Hatches #1 and #2 fitted with Container Guides	Yes	Yes			
103	When containers are carried seven high, the load imposed on the lowest container in the tier shall not exceed 100 L. T.		Yes			
104	When lighters or containers, or both, are carried on hatch covers, the hatch cover load shall not exceed 527 L. T. for lighters or 720 L. T. for containers.		Yes			
105	Alternate stowage of containers and lighters require major changes in guide structure.	Yes	Yes			
106	The container crane would have to be removed to stow lighters at Hold 1a.	Yes	Yes			
107	Maximum lift operating position of container gantry crane.	93'-0" A.B.L.	93'-0" A.B.L.			
108	When containers are required to be stowed seven high and weigh more than 15 tons, the 7th container tier must be carried empty. If the first (6) tiers weigh less than 15 tons each, the balance or part of the balance of the load to make up may be carried in the 7th tier of containers.	Yes				
109	A total of 62 lighters may be carried if stowed two high on the main deck and hold and hatch covers, but the upper lighter must be empty if the lower lighter is full. Lower Lighter - 410 S.T. Upper Lighter - Empty Lower Lighter - 273.33 S.T. Upper Lighter - 136.67 S.T.	Yes				

PRINCIPAL CHARACTERISTICS	PRUDENTIAL GRACE LINES	PACIFIC FAR EAST LINE
LENGTH OVERALL INCLUDING OVERHANG	820'-0"	820'-0"
LENGTH OVERALL EXCLUDING CRANE OVERHANG	772'-0"	772'-0"
LENGTH BETWEEN PERPENDICULARS	724'-0"	724'-0"
MOLDED BREATH (BEAM)	100'-0"	100'-0"
DEPTH (MOLDED) AT THE SIDE	60'-0"	60'-0"
SHAFT HORSEPOWER (ABS MAX)	32000	32000
SPEED NORMAL @ 28 WL	22.5 KNOTS	22.5 KNOTS
DRAFT DESIGN	28'-0"	28'-0"
DEADWEIGHT TONNAGE @ 28' WL	17990 LT	17990 LT
FULL LOAD DRAFT	35'-1 1/2"	35'-1 3/16"
DEADWEIGHT TONNAGE @ FULL LOAD DRAFT	29820 LT	29749 LT
U.S. GROSS TONNAGE	26406	26456
U.S. NET TONNAGE	18706	18706
MAIN PROPULSION	STEAM	STEAM
ENDURANCE (NAUTICAL MILES)	15000	15000
NUMBER OF PROPELLERS	ONE	ONE
LIGHTER GANTRY CRANE (CAPACITY)	500 ST	500 ST
LIGHTER GANTRY CRANE (BUILDER)	ALLIANCE	ALLIANCE
CONTAINER GANTRY CRANE (BUILDER)	PAECO	PAECO
DISPLACEMENT (DESIGN)	32761 LT	32700 LT
NO. OF SHIPS	5	6

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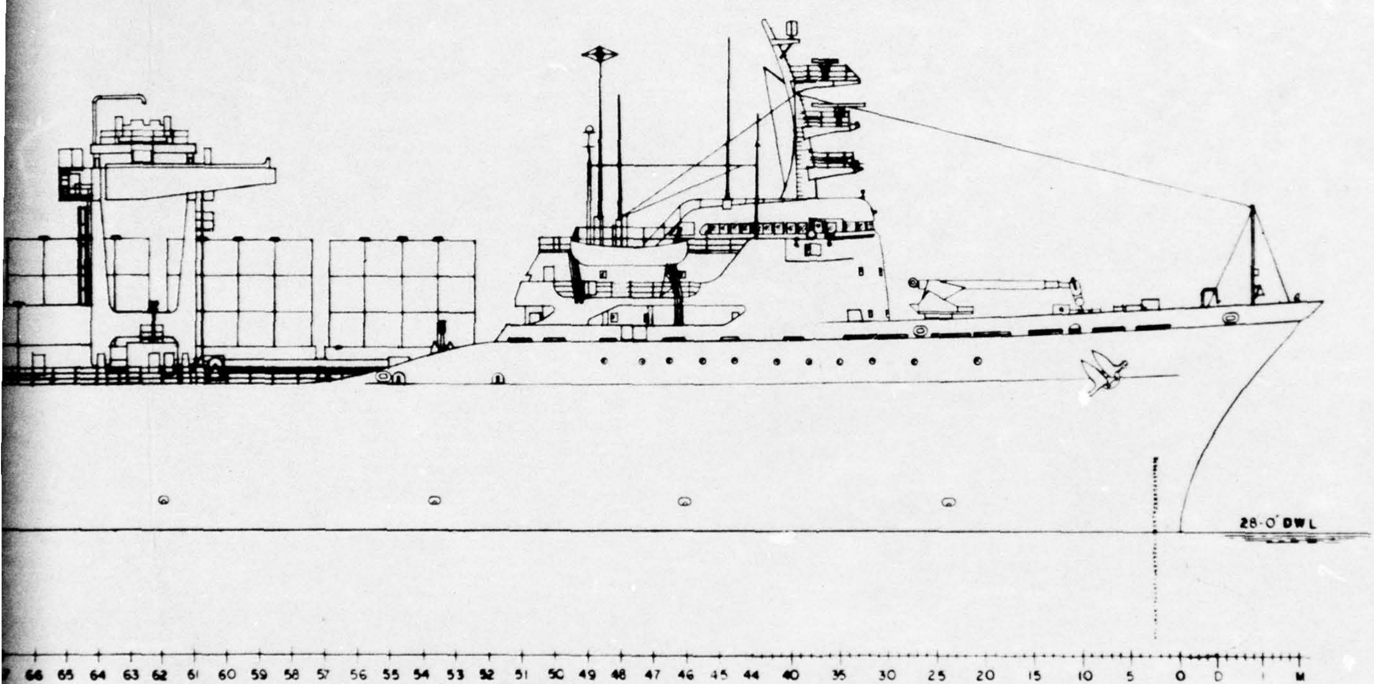
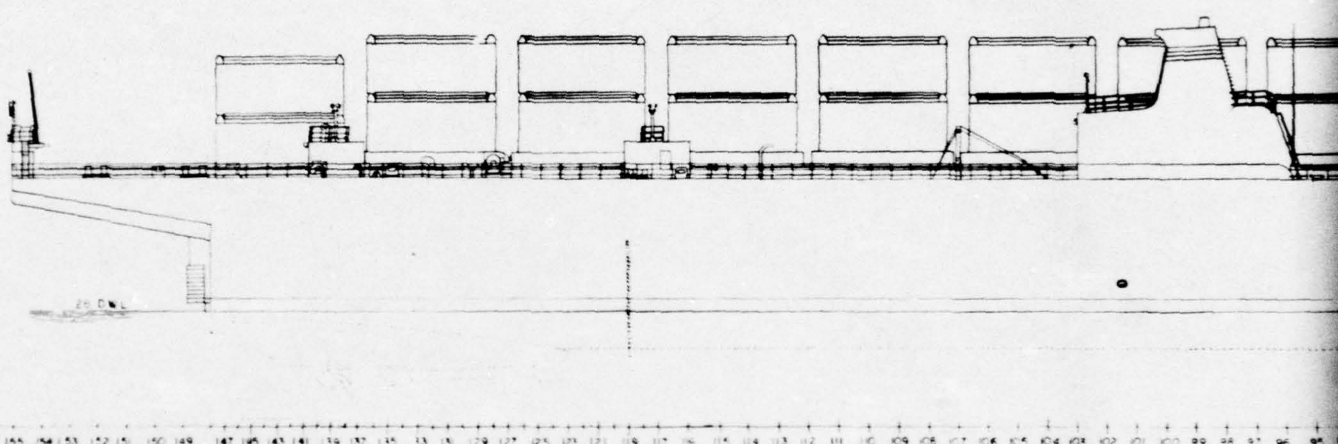
2

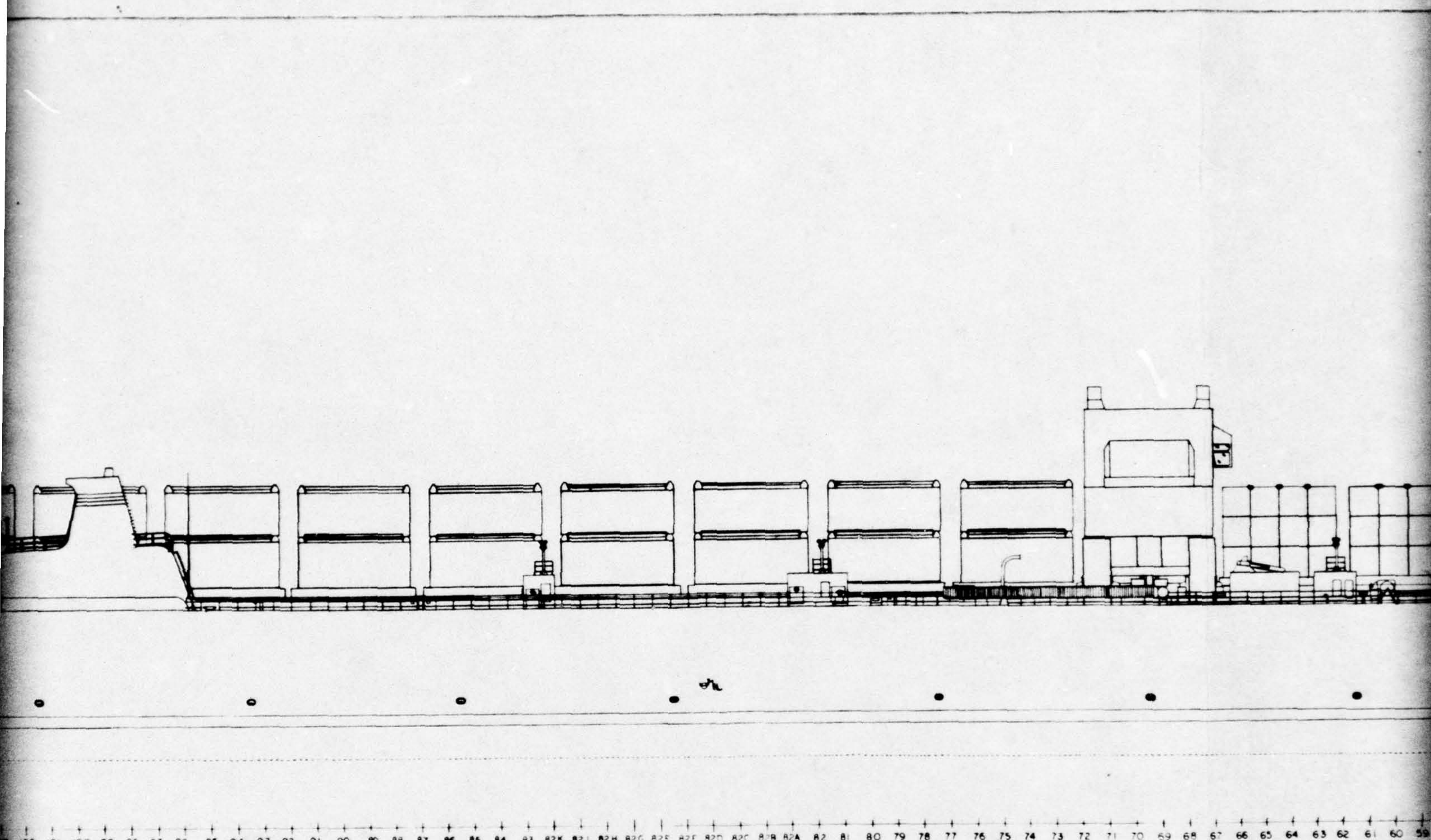


PACIFIC FAR EAST LINE
MA DESIGN C8-S-81b
MA HULL NOS 231 232 233 234 235 236
PRUDENTIAL GRACE LINES
MA DESIGN C8-S-81b
MA HULL NOS 228 229 230 236 237
OUTBOARD PROFILE

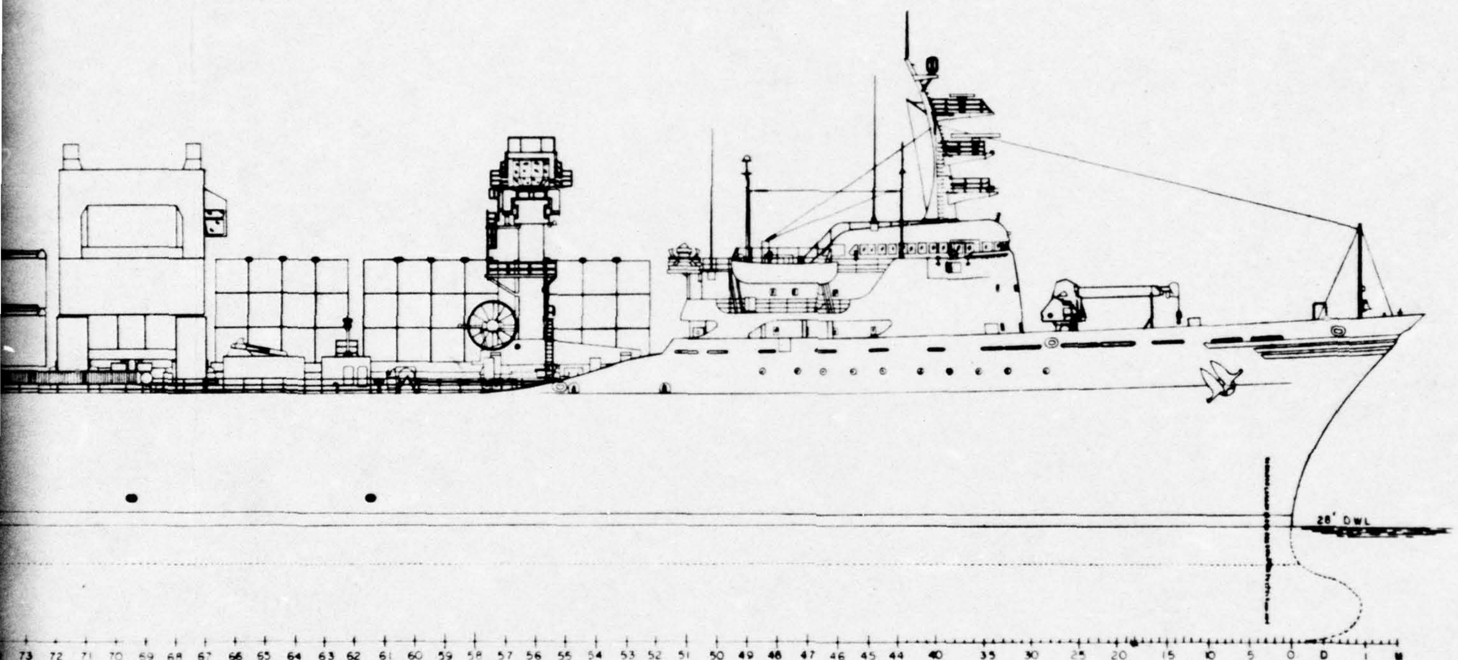
FIGURE 2.1

PRINCIPAL CHARACTERISTICS	DELTA STEAM SHIP LINES
LENGTH OVERALL INCLUDING OVERHANG	893'-4"
LENGTH OVERALL EXCLUDING CRANE OVERHANG	845'-4"
LENGTH BETWEEN PERPENDICULARS	797'-4"
MOLDED BREADTH (BEAM)	100'-0"
DEPTH (MOLDED) AT THE SIDE	60'-0"
SHAFT HORSEPOWER (ABS MAX)	32000
SPEED NORMAL @ 28 W.L.	22 KNOTS
DRAFT DESIGN	28'-0"
DEADWEIGHT TONNAGE @ 28' W.L.	21552 L.T.
FULL LOAD DRAFT	38'-1 1/2"
DEADWEIGHT TONNAGE @ FULL LOAD DRAFT	40592 L.T.
U.S. GROSS TONNAGE	32269
U.S. NET TONNAGE	24767
MAIN PROPULSION	STEAM
ENDURANCE (NAUTICAL MILES)	15000
NUMBER OF PROPELLERS	ONE
LIGHTER GANTRY CRANE (CAPACITY)	510 S.T.
LIGHTER GANTRY CRANE (BUILDER)	MORGAN
CONTAINER GANTRY CRANE (BUILDER)	SKAGIT
DISPLACEMENT (DESIGN)	38062 L.T.
NO. OF SHIPS	3




102 101 100 99 98 97 96 95 94 93 92 91 90 89 88 87 86 85 84 83 82K 82J 82H 82G 82F 82F 82D 82C 82B 82A 82 81 80 79 78 77 76 75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 59

2

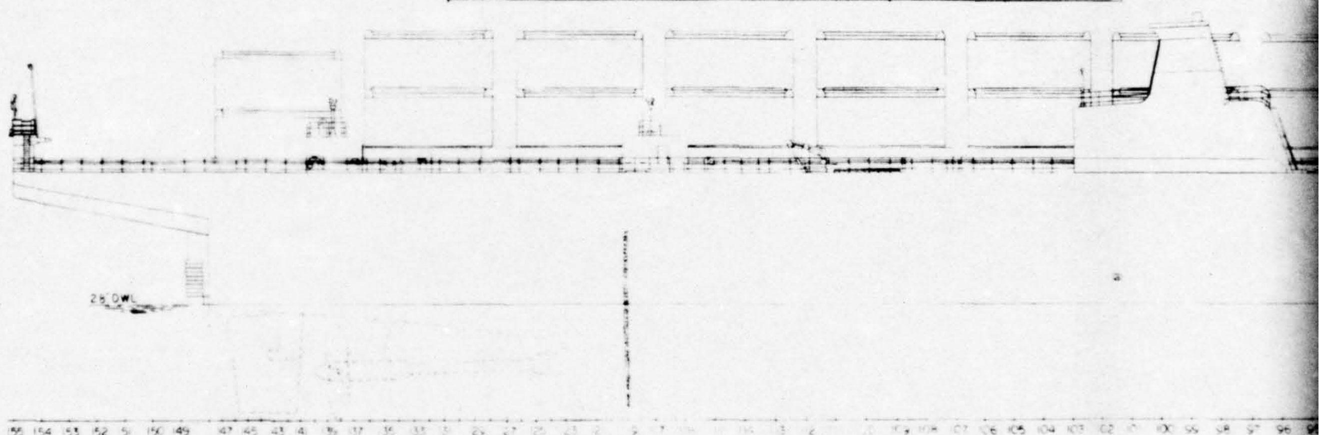


COPY AVAILABLE TO DDC DOES NOT PERMIT FULLY LEGIBLE PRODUCTION

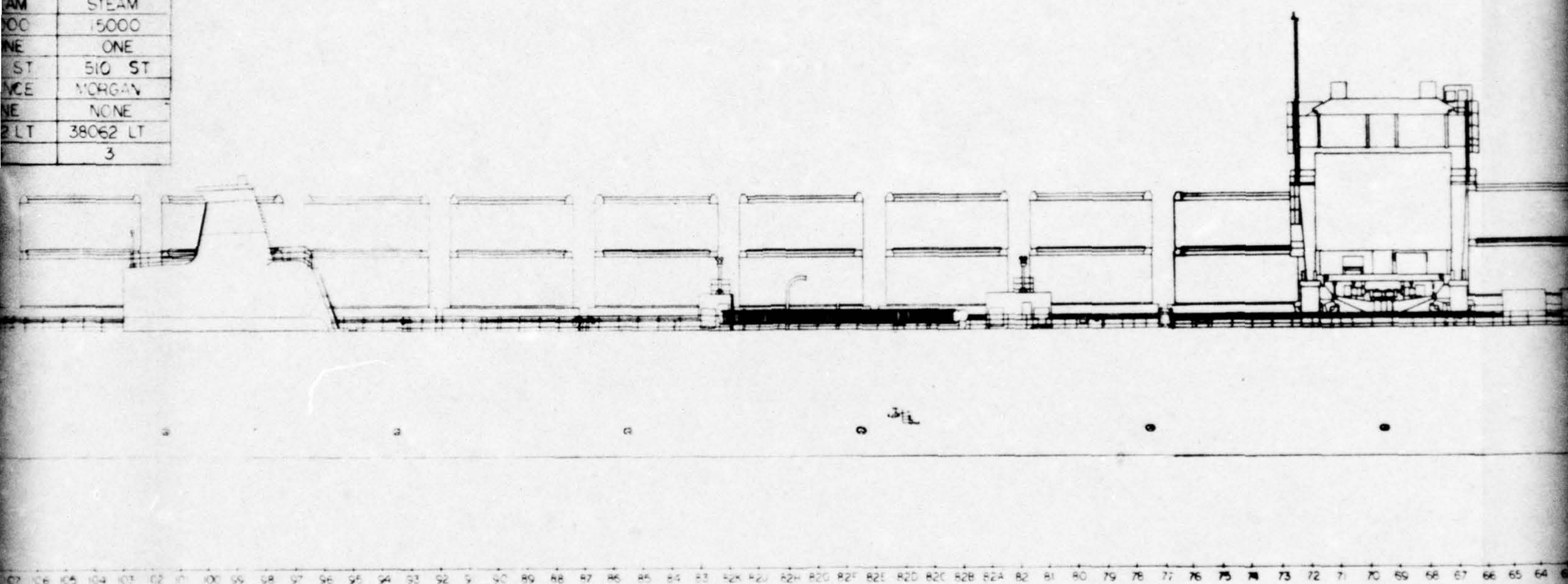
DELTA STEAM SHIP LINES
MA DESIGN C9-S-81d
MA HULL NOS 259 260 261
OUTBOARD PROFILE

FIGURE 2.2

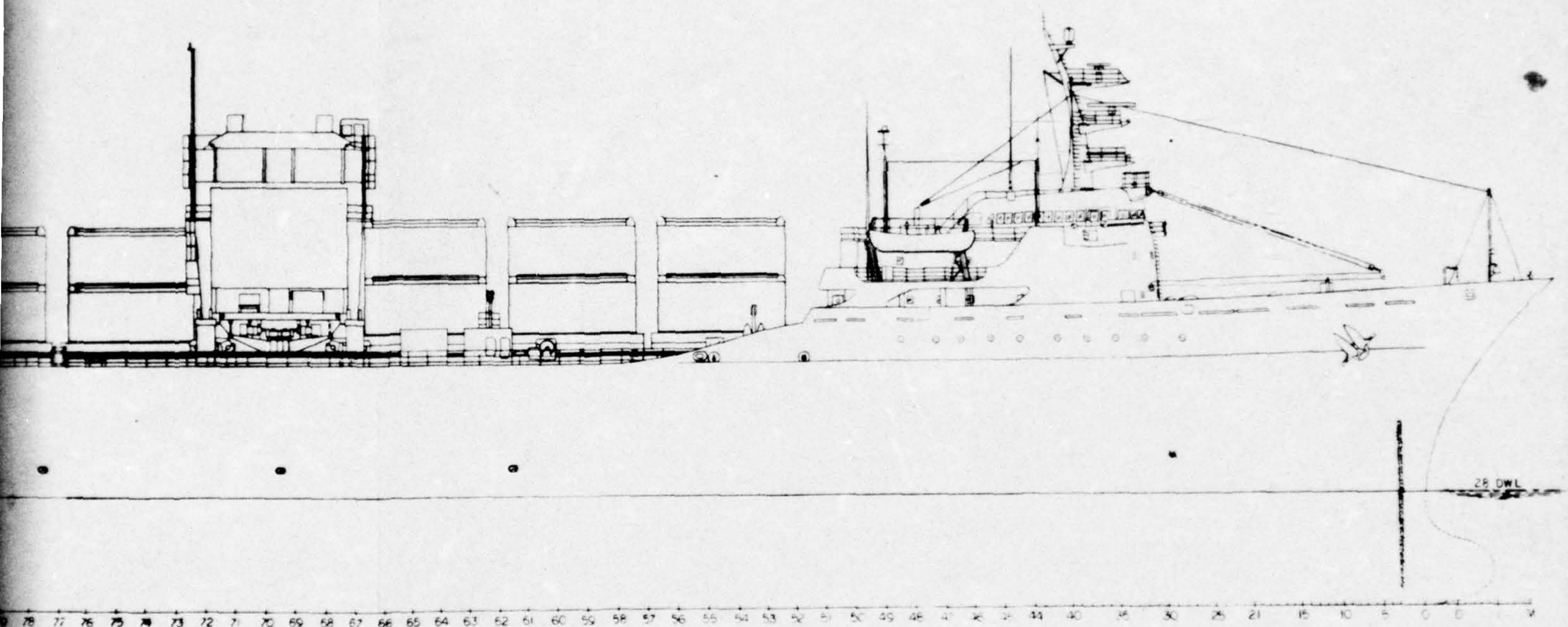
PRINCIPAL CHARACTERISTICS	WATERMAN STEAMSHIP CORP	CENTRAL GULF STEAMSHIP CORP
LENGTH OVERALL INCLUDING OVERHANG	893 - 4"	893' - 4"
LENGTH OVERALL EXCLUDING CRANE OVERHANG	845 - 4"	845' - 4"
LENGTH BETWEEN PERPENDICULARS	797' - 4"	797' - 4"
MOLDED BREADTH (BEAM)	100' - 0"	100' - 0"
DEPTH (MOLDED) AT THE SIDE	60' - 0"	60' - 0"
SHAFT HORSE POWER (ABS MAX)	32000	32000
SPEED NORMAL @ 28' W.L.	22 KNOTS	22 KNOTS
DRAFT DESIGN	28' 0"	28' 0"
DEADWEIGHT TONNAGE @ 28' W.L.	21901 LT	21901 LT
FULL LOAD DRAFT	38'-1½"	38'-1½"
DEADWEIGHT TONNAGE @ FULL LOAD DRAFT	40679 LT	40679 LT
U.S. GROSS TONNAGE	32269	32269
U.S. NET TONNAGE	24757	24757
MAIN PROPULSION	STEAM	STEAM
ENDURANCE (NAUTICAL MILES)	15000	15000
NUMBER OF PROPELLERS	ONE	ONE
LIGHTER GANTRY CRANE (CAPACITY)	500 ST	510 ST
LIGHTER GANTRY CRANE (BUILDER)	ALLIANCE	MORGAN
CONTAINER GANTRY CRANE (BUILDER)	NONE	NONE
DISPLACEMENT (DESIGN)	38062 LT	38062 LT
NO. OF SHIPS	3	3



…MAN …IP CORP	CENTRAL GULF STEAMSHIP CORP
…4"	893'- 4"
…4"	845'- 4"
…4"	797'- 4"
…0"	100' - 0"
…0"	60' - 0"
…00	32000
…NOTS	22 KNOTS
…0"	28' 0"
…LT	21901 LT
…1½"	38'-1½"
…LT	40679 LT
…269	32269
…767	24767
…AM	STEAM
…000	15000
…NE	ONE
…ST	510 ST
…NCE	MORGAN
…NE	NONE
…2 LT	38062 LT
	3



2

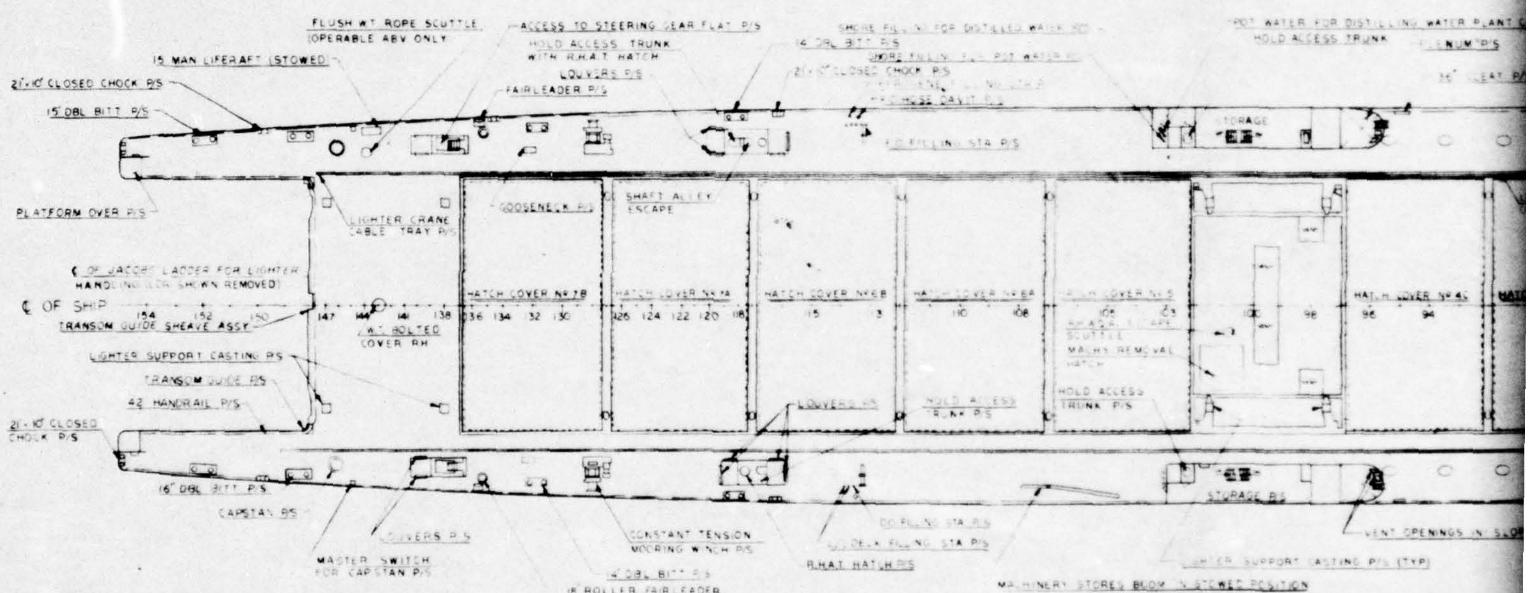


CENTRAL GULF STEAMSHIP CORPORATIO
M.A. DESIGN C9-S-81d
M.A. HULL NOS.-265 274&2
WATERMAN STEAMSHIP CORPORATION
M.A. DESIGN C9-S-81d
M.A. HULL NOS.-262, 263 &
OUTBOARD PROFILE

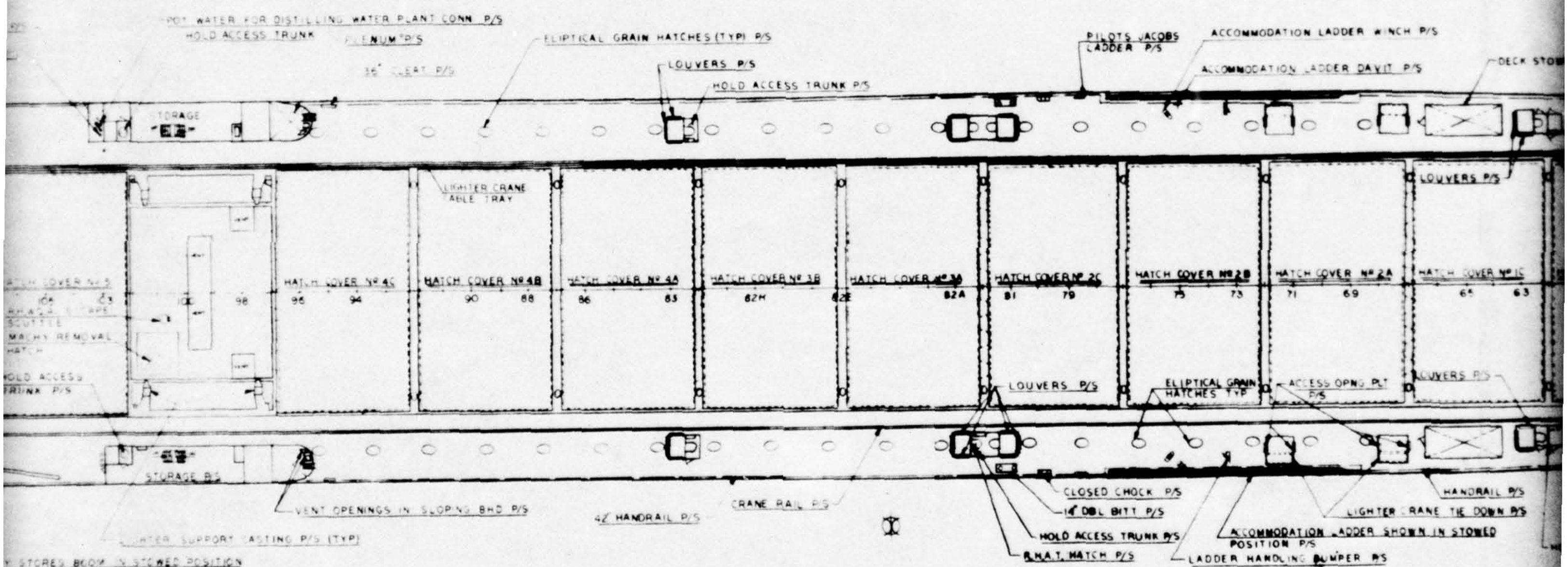
FIGURE 2

2-15/2-

3



FLUSH W.T. ROPE SCUTTLE (OPERABLE ABV ONLY)
ACCESS TO STEERING GEAR FLAT P/S
HOLD ACCESS TRUNK WITH R.H.A.T. HATCH
LOUVERS P/S
FAIRLEADER P/S
15 MAN LIFERAFT (STOWED)
21 x 10 CLOSED CHOCK P/S
15 DBL BITT P/S
14 DBL BITT P/S
21 x 10 CLOSED CHOCK P/S
HOLD ACCESS TRUNK
STORAGE
PLATFORM OVER P/S
LIGHTER CRANE CABLE TRAY P/S
GOOSENECK P/S
SHAFT ALLEY ESCAPE
℄ OF JACOBS LADDER FOR LIGHTER HANDLING (OR SHOWN REMOVED)
℄ OF SHIP
TRANSOM GUIDE SHEAVE ASSY
W.T. BOLTED COVER RH
HATCH COVER NR 7B
HATCH COVER NR 7A
HATCH COVER NR 6B
HATCH COVER NR 6A
HATCH COVER NR 5
HATCH COVER NR 4
154 152 150 147 144 141 138 136 134 132 130 126 124 122 120 118 115 113 110 108 105 103 100 98 96 94
SCUTTLE
MACHY REMOVAL HATCH
LIGHTER SUPPORT CASTING P/S
TRANSOM GUIDE P/S
42 HANDRAIL P/S
21 x 10 CLOSED CHOCK P/S
LOUVERS P/S
HOLD ACCESS TRUNK P/S
HOLD ACCESS TRUNK P/S
16 DBL BITT P/S
CAPSTAN P/S
LOUVERS P/S
MASTER SWITCH FOR CAPSTAN P/S
CONSTANT TENSION MOORING WINCH P/S
14 DBL BITT P/S
18 ROLLER FAIRLEADER
R.H.A.T. HATCH P/S
STORAGE P/S
VENT OPENINGS IN SLO
LIGHTER SUPPORT CASTING P/S (TYP)
MACHINERY STORES BOOM IN STOWED POSITION


POT WATER FOR DISTILLING WATER PLANT CONN P/S
HOLD ACCESS TRUNK
PLENUM P/S
ELIPTICAL GRAIN HATCHES (TYP) P/S
LOUVERS P/S
HOLD ACCESS TRUNK P/S
PILOTS JACOBS LADDER P/S
ACCOMMODATION LADDER WINCH P/S
ACCOMMODATION LADDER DAVIT P/S
STORAGE
LIGHTER CRANE CABLE TRAY
HATCH COVER Nº 4C
HATCH COVER Nº 4B
HATCH COVER Nº 4A
HATCH COVER Nº 3B
HATCH COVER Nº 2B
HATCH COVER Nº 2A
LOUVERS P/S
ELIPTICAL GRAIN HATCHES TYP
ACCESS OPNG PLT P/S
STORAGE P/S
VENT OPENINGS IN SLOPING BHD P/S
42 HANDRAIL P/S
CRANE RAIL P/S
CLOSED CHOCK P/S
DBL BITT P/S
HOLD ACCESS TRUNK P/S
ACCOMMODATION LADDER SHOWN IN STOWED POSITION P/S
LADDER HANDLING BUMPER P/S
HANDRAIL P/S
LIGHTER CRANE TIE DOWN P/S
LIGHTER SUPPORT CASTING P/S (TYP)
STORES BOOM IN STOWED POSITION

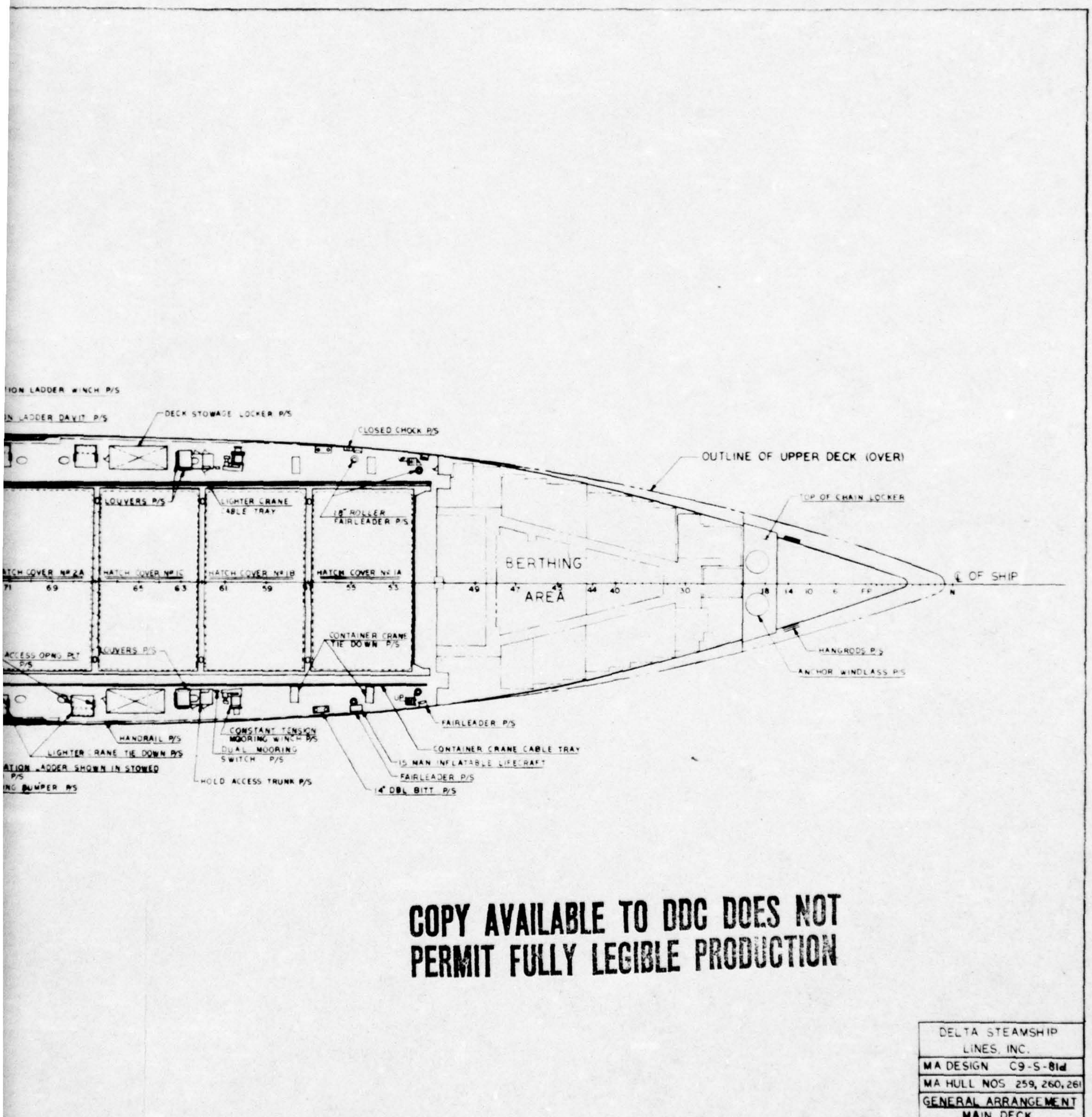
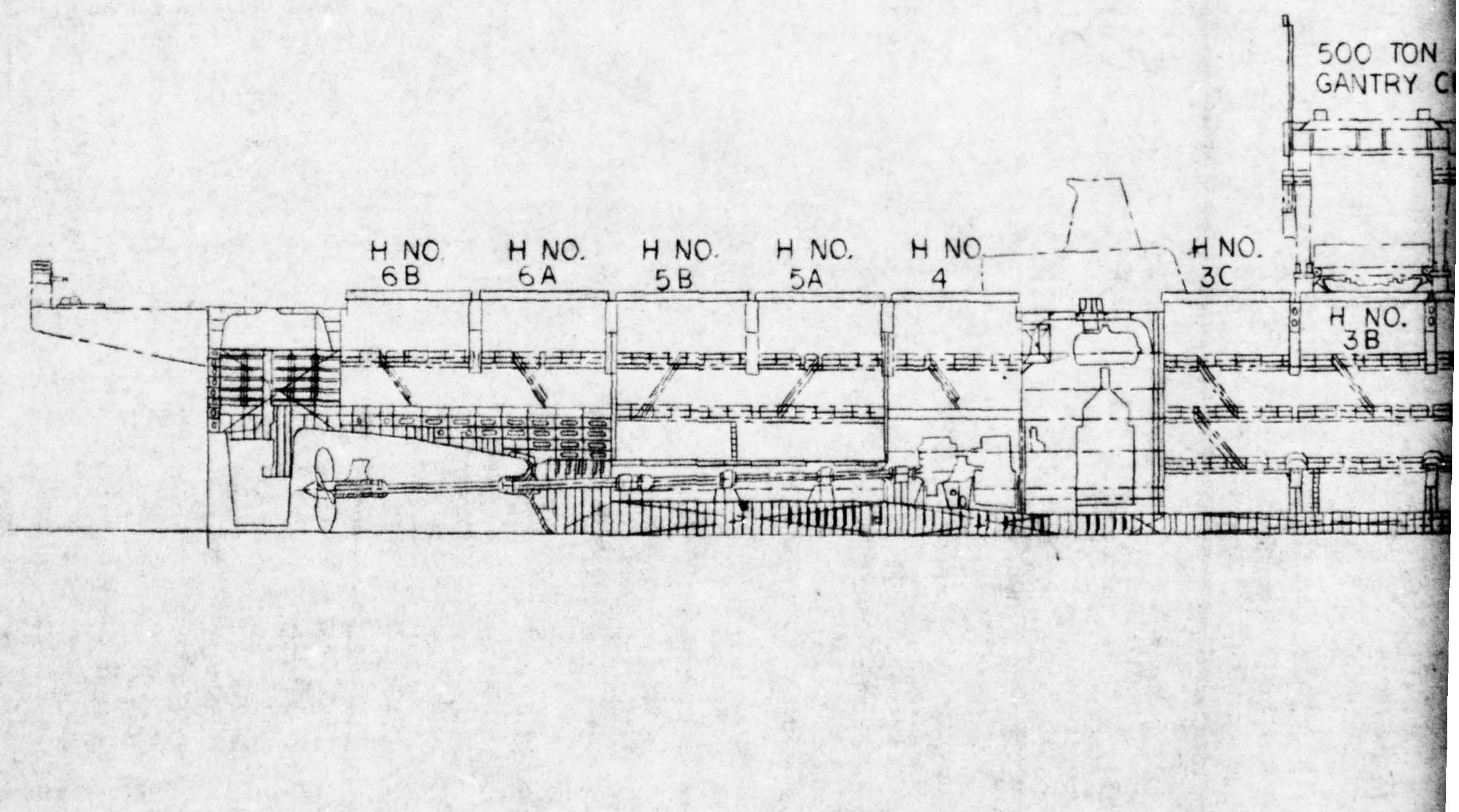
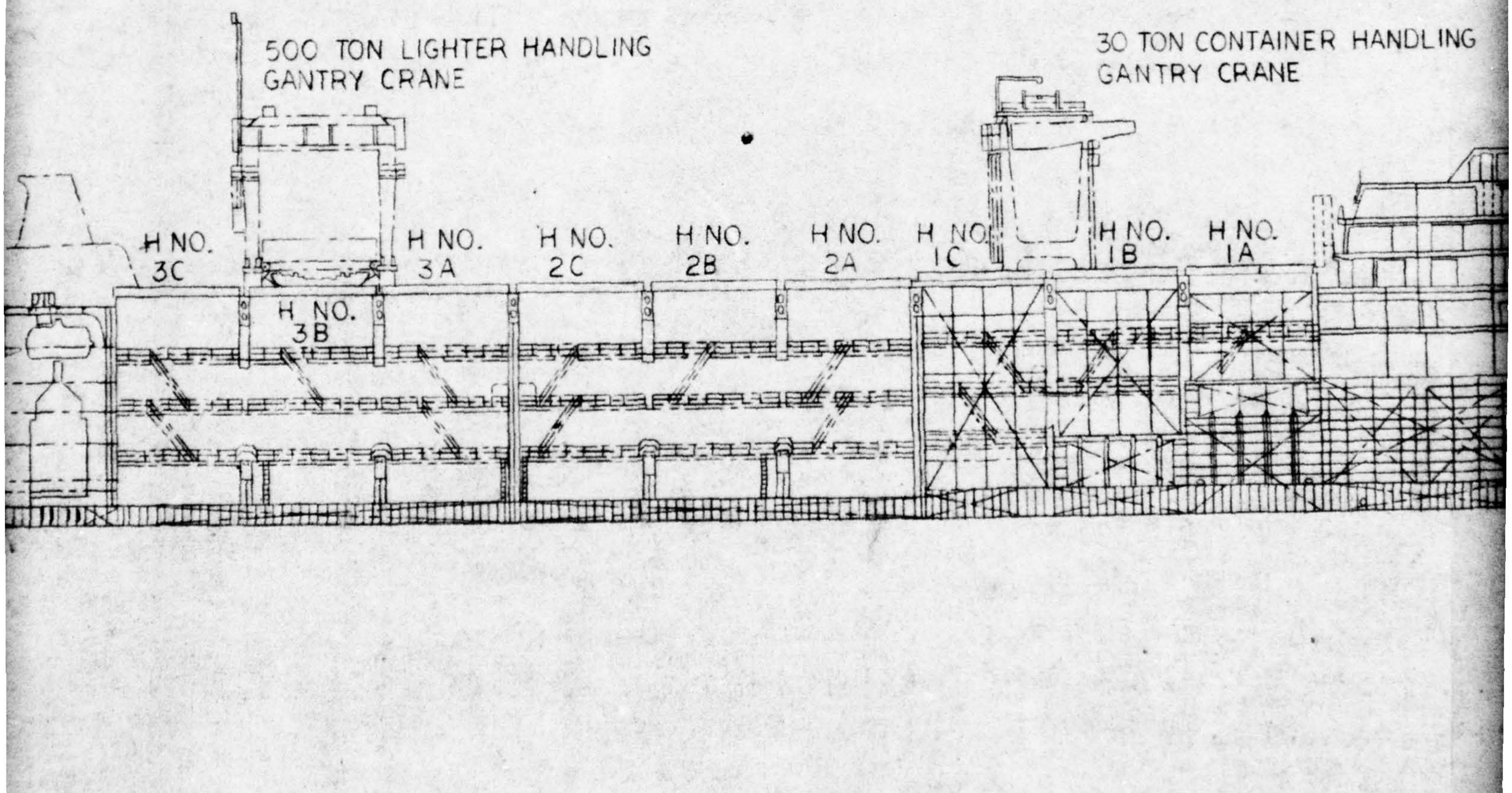

DECK STOWAGE LOCKER P/S
CLOSED CHOCK P/S
OUTLINE OF UPPER DECK (OVER)
TOP OF CHAIN LOCKER
LOUVERS P/S
LIGHTER CRANE
CABLE TRAY
18" ROLLER
FAIRLEADER P/S
BERTHING
AREA
℄ OF SHIP
HATCH COVER Nº 2A
HATCH COVER Nº 1C
HATCH COVER Nº 1B
HATCH COVER Nº 1A
CONTAINER CRANE
TIE DOWN P/S
HANGRODS P/S
ANCHOR WINDLASS P/S
FAIRLEADER P/S
CONTAINER CRANE CABLE TRAY
HANDRAIL P/S
CONSTANT TENSION
MOORING WINCH P/S
LIGHTER CRANE TIE DOWN P/S
DUAL MOORING
SWITCH P/S
15 MAN INFLATABLE LIFECRAFT
FAIRLEADER P/S
HOLD ACCESS TRUNK P/S
14" DBL BITT P/S
DELTA STEAMSHIP
LINES, INC.
MA DESIGN C9-S-81d
MA HULL NOS 259, 260, 261
GENERAL ARRANGEMENT
MAIN DECK

FIGURE 2.4

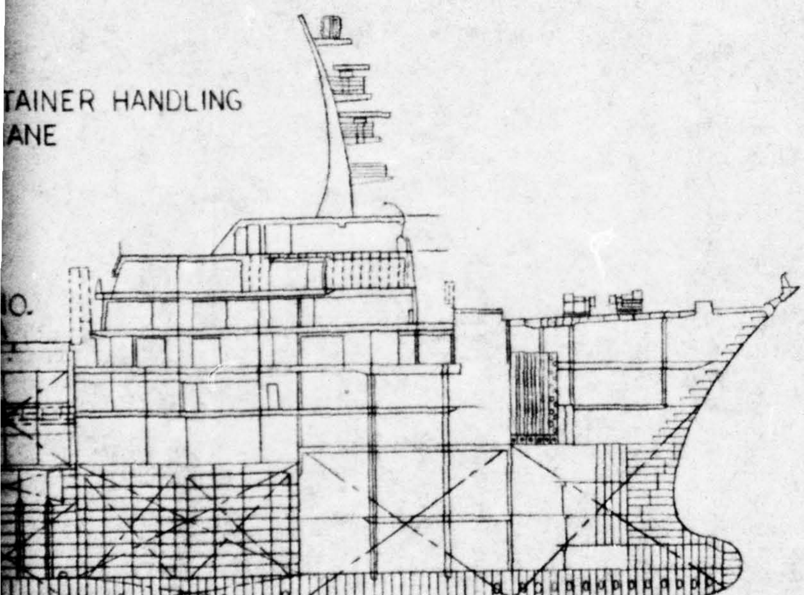
3



500 TON
GANTRY C
H NO.
6B
H NO.
6A
H NO.
5B
H NO.
5A
H NO.
4
H NO.
3C
H NO.
3B



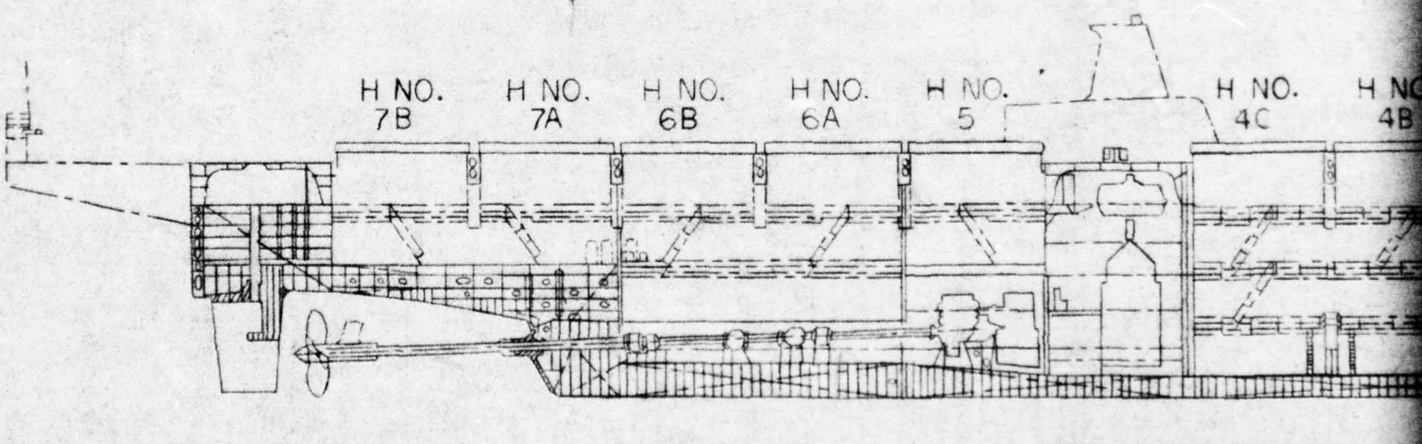
500 TON LIGHTER HANDLING
GANTRY CRANE
30 TON CONTAINER HANDLING
GANTRY CRANE
H NO. 3C
H NO. 3B
H NO. 3A
H NO. 2C
H NO. 2B
H NO. 2A
H NO. 1C
H NO. 1B
H NO. 1A

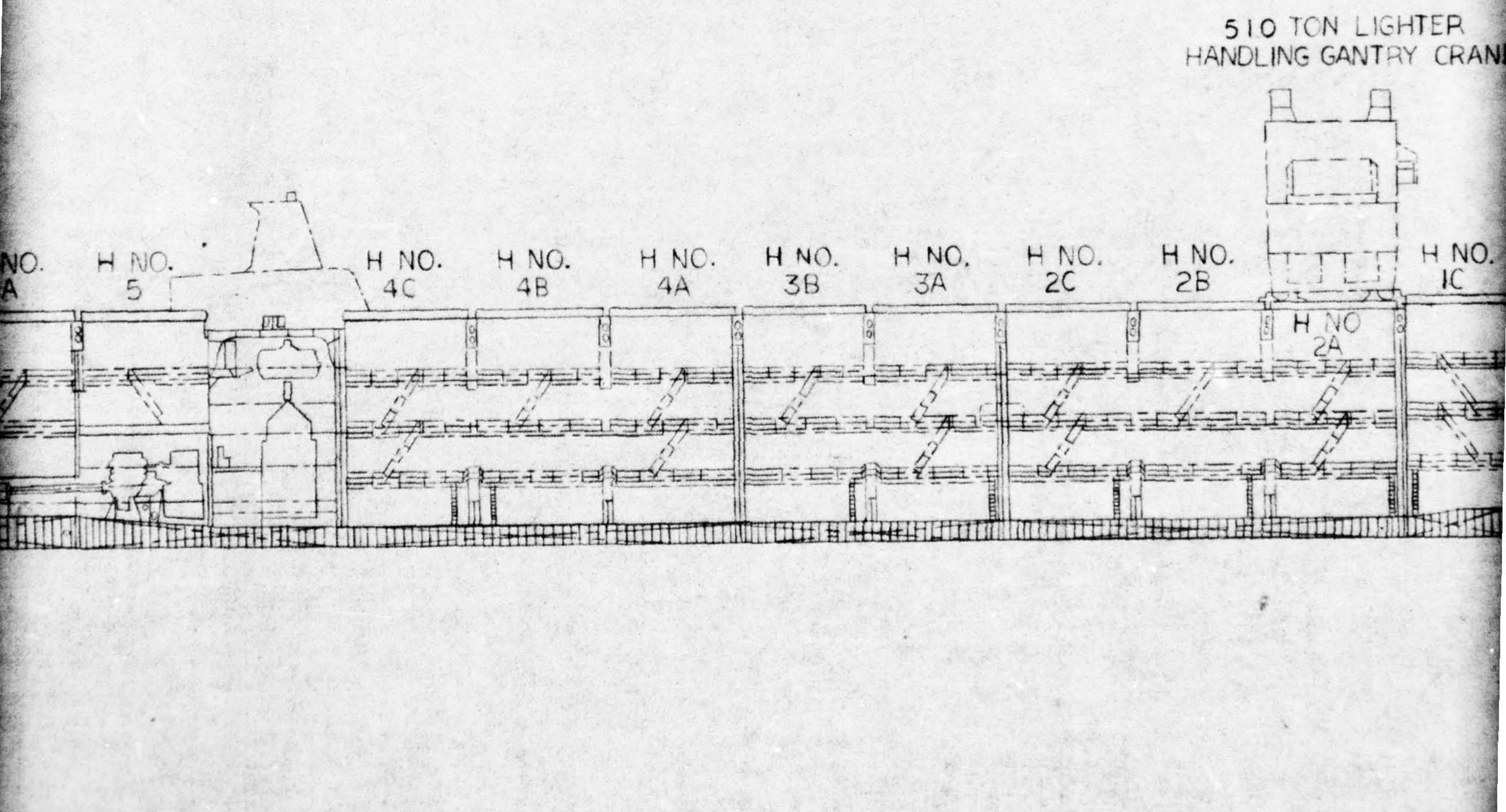


PRUDENTIAL LINES INC.
AND
PACIFIC FAR EAST LINES
M.A. DESIGN C8-S-81b F&G DESIGN 9291

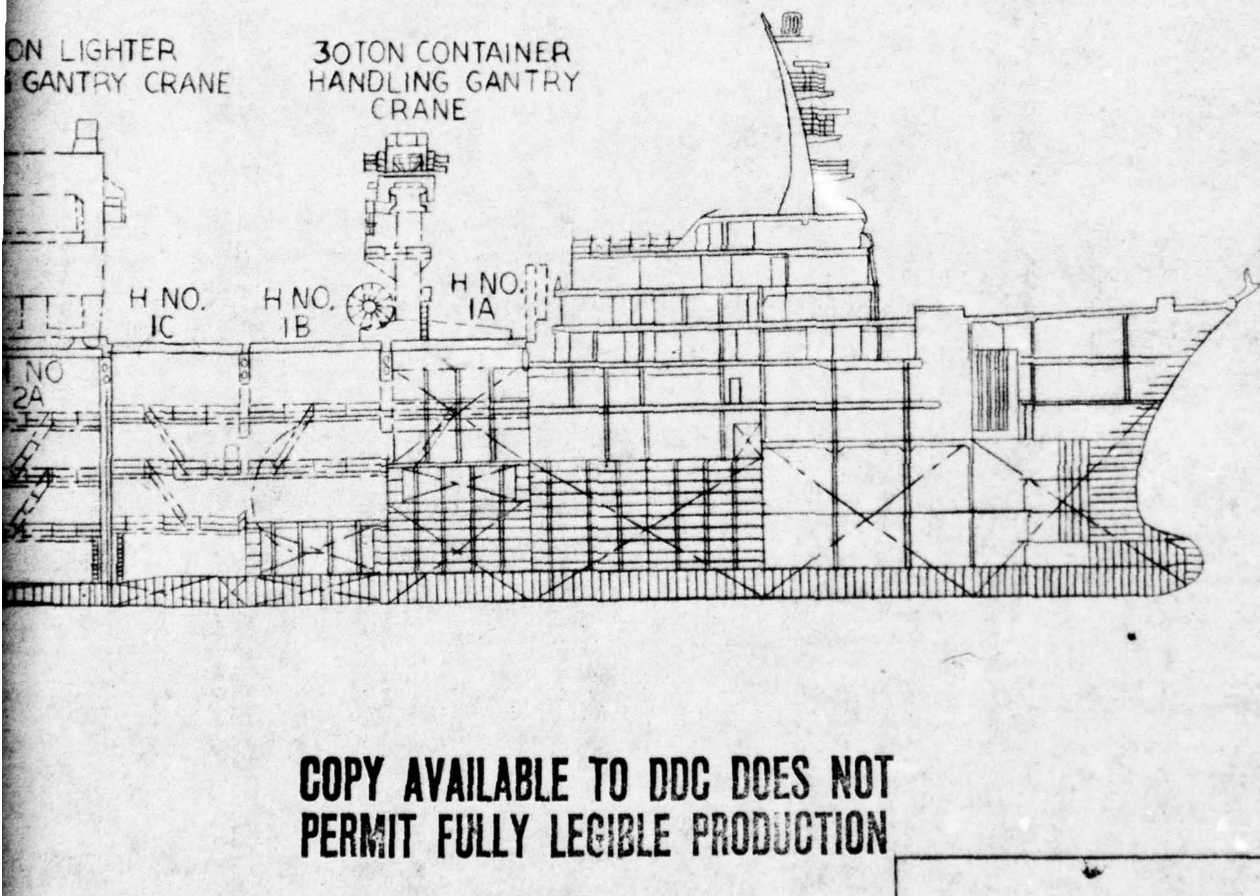
INBOARD PROFILE

FIGURE NO. 2.5


H NO. 7B
H NO. 7A
H NO. 6B
H NO. 6A
H NO. 5
H NO. 4C
H NO. 4B



510 TON LIGHTER
HANDLING GANTRY CRANE
NO.
A
H NO.
5
H NO.
4C
H NO.
4B
H NO.
4A
H NO.
3B
H NO.
3A
H NO.
2C
H NO.
2B
H NO
2A
H NO.
1C



DELTA STEAMSHIP LINES INC.
M A DESIGN C9-S-81d F&G DESIGN 9397
INBOARD PROFILE

3

FIGURE NO. 2.6

3. CANDIDATE OUTSIZE CARGO

Table 3.1 lists the candidate outsize cargo components to be lifted for LAPS. The principal items are components of the elevated causeway system. These items are in general too large and/or heavy to transport to, and discharge at, an amphibious objective area except by Navy Amphibious Ships. The elevated causeway system is required by the Navy to support the U. S. Marine Corps in an assault follow-on resupply.

Throughout the remainder of this report, outsize cargo components will be referred to by name and/or the item number shown in Table 3.1, e.g., Item 1 is a 3 x 15 P-Series Pontoon Causeway Intermediate Section. Item 1, like several other items, is further divided, i.e., Item 1a is a standard 3 x 15 P-Series Pontoon Causeway Intermediate Section and Item 1b is a 3 x 15 P-Series Pontoon Causeway Intermediate Section with 4 Internal Spudwells, etc.

In Table 3.1, the values shown in the column labeled 'Load Capacity (Kips)' indicate the remaining load capacity of the causeway component to maintain a one (1) foot freeboard. That is, the value listed is the difference between the load the causeway can carry in addition to its own weight and still maintain a one foot freeboard. See Note 3 of the table.

The length and widths shown in Table 3.1 are the maximum values for the causeway or its load. Thus, the values shown are the minimum length and width for a causeway/crane combination or the actual length and width for a single item. Without dismantling a component or its load, the value shown cannot be decreased. The actual length of an outside cargo component could exceed the value shown if, for example, the crane is moved to position the center of gravity (C.G.) of the crane over the C. G. of the causeway.

The heights shown in Table 3.1 account for the fact that the load on a causeway is loaded on the causeway deck and not on the highest point of the causeway.

Three dimensional sketches of some of the outsize cargo components are included in the following illustrations:

Figure 3.1 - AMMI Pontoon Causeway.

Figure 3.2 - LCM-8.

Figure 3.3 - 3 x 15 Standard Causeway Intermediate Section.

Figure 3.4 - Water-jet Propelled Causeway.

Figure 3.5 - 4 x 15 NL Pontoon Causeway with MK 60 Bucyrus Erie Crane (60 foot boom).

Figure 3.6 - 4 x 15 Pontoon Causeway with External Spudwells.

Figure 3.7 - 4 x 15 Pontoon Causeway with Internal Spudwells.

Figure 3.8 - 3 x 14 Warping Tug with Outboard Motor.

A List of Facts and Assumptions employed in calculating lift capabilities is outlined in Table 3.2.

TABLE 3.1 CANDIDATE OUTSIZE CARGO COMPONENTS

Item	Outsize Cargo Component			Weight (Kips)[1]	Load Capacity (Kips)[1]	Dimensions (Ft-In)			C.G. (Ft) Dist. From Fwd. End.[4]	Remarks
						Length	Width or Dia.	Height		
1	3x15 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	137	183	92-0	21-3	5-3	46.0	Note 2, 3
		b	4 Internal Spudwells	142	142	92-0	21-3	6-0	46.0	Note 3
		c	4 External Spudwells	142	178	92-0	27-0	6-0	46.0	Note 3
		d	6 Internal Spudwells	144	122	92-0	21-3	6-0	46.0	Note 3
		e	6 External Spudwells	144	176	92-0	27-0	6-0	46.0	Note 3
2	4x15 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	183	244	92-0	28-4	5-3	46.0	Note 2, 3
		b	4 Internal Spudwells	188	203	92-0	28-4	6-0	46.0	Note 3
		c	4 External Spudwells	188	239	92-0	34-1	6-0	46.0	Note 3
		d	6 Internal Spudwells	190	183	92-0	28-4	6-0	46.0	Note 3
		e	6 External Spudwells	190	237	92-0	34-1	6-0	46.0	Note 3
3	4x10 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	122	163	61-1	28-4	5-3	30.5	Note 2, 3
		b	4 Internal Spudwells	127	122	61-1	28-4	6-0	30.5	Note 3
		c	4 External Spudwells	127	158	61-1	34-1	6-0	30.5	Note 3
4	AMMI Pontoon Causeway			110	535	90-0	28-0	5-0	45.0	Note 3

TABLE 3.1 CANDIDATE OUTSIZE CARGO COMPONENTS (Continued)

Item	Outsize Cargo Component			Weight (Kips)1	Load Capacity (Kips)1	Dimensions (Ft-In) Length	Width or Dia.	Height	C.G. (Ft) Dist. From Fwd. End.4	Remarks
5	Piling	a	Single	6.2	-	60-0	1-8 ø	-	30.0	
		b	Bundle of 3	18.7	-	60-0	3-4	3-2	30.0	
6	Water-Jet Propelled Causeway			205.3	151	90-0	21-3	6-0	37.0	Note 3
7	3 x 14 Pontoon Warping Tug (P-Series)			194	105	90-0	21-3	15-9	39.0	Note 3
8	Side Loadable Warping Tug	a	w/outboard propulsion	227	93	91-0	21-3	7-7	39.0	Note 3
		b	w/water-jet propulsion	230	90	91-8	21-3	7-7	38.7	Note 3
9	LCM-6			56	-	56-2	14-1	13-4	21.5	
10	LCM-8	a	Aluminum Hull	115	-	74-3	21-1	15-0	30.1	
		b	Steel Hull	134	-	73-8	21-1	15-0	32.8	

TABLE 3.1 CANDIDATE OUTSIZE CARGO COMPONENTS (Continued)

Item	Outsize Cargo Component			Weight (Kips)1	Load Capacity (Kips)1	Dimensions (Ft-In) Length	Width or Dia.	Height	C.G. (Ft) Dist. From Fwd. End.4	Remarks
11	Bucyrus-Erie MK-100 Marine Crane w/60' Boom	a	Bare Crane	111	-	92-0	17-10	12-0	11.0	
		b	On 3x15 Causeway w/6 Ext. Spudwells	255	65	92-0	27-0	17-3	Variable	Note 3
		c	On 4x15 Causeway w/6 Ext. Spudwells	301	126	92-0	34-1	17-3	Variable	Note 3
	(A-Frame Lowered)	d	On 4x10 Causeway w/4 Ext. Spudwells	238	47	92-0	34-1	17-3	Variable	Note 3
		e	On AMMI Causeway	221	265	92-0	28-0	17-0	Variable	Note 3
12	P & H 9125 Truck Crane w/60' Boom	a	Bare Crane	190	-	94-0	11-1	13-2	15.0	
		b	On 3x15 Std. Causeway	327	-7	94-0	27-0	18-5	Variable	Note 3
		c	On 4x15 Causeway w/6 Ext. Spudwells	380	47	94-0	34-1	18-5	Variable	Note 3
		d	On AMMI Causeway	300	186	94-0	28-0	18-2	Variable	Note 3

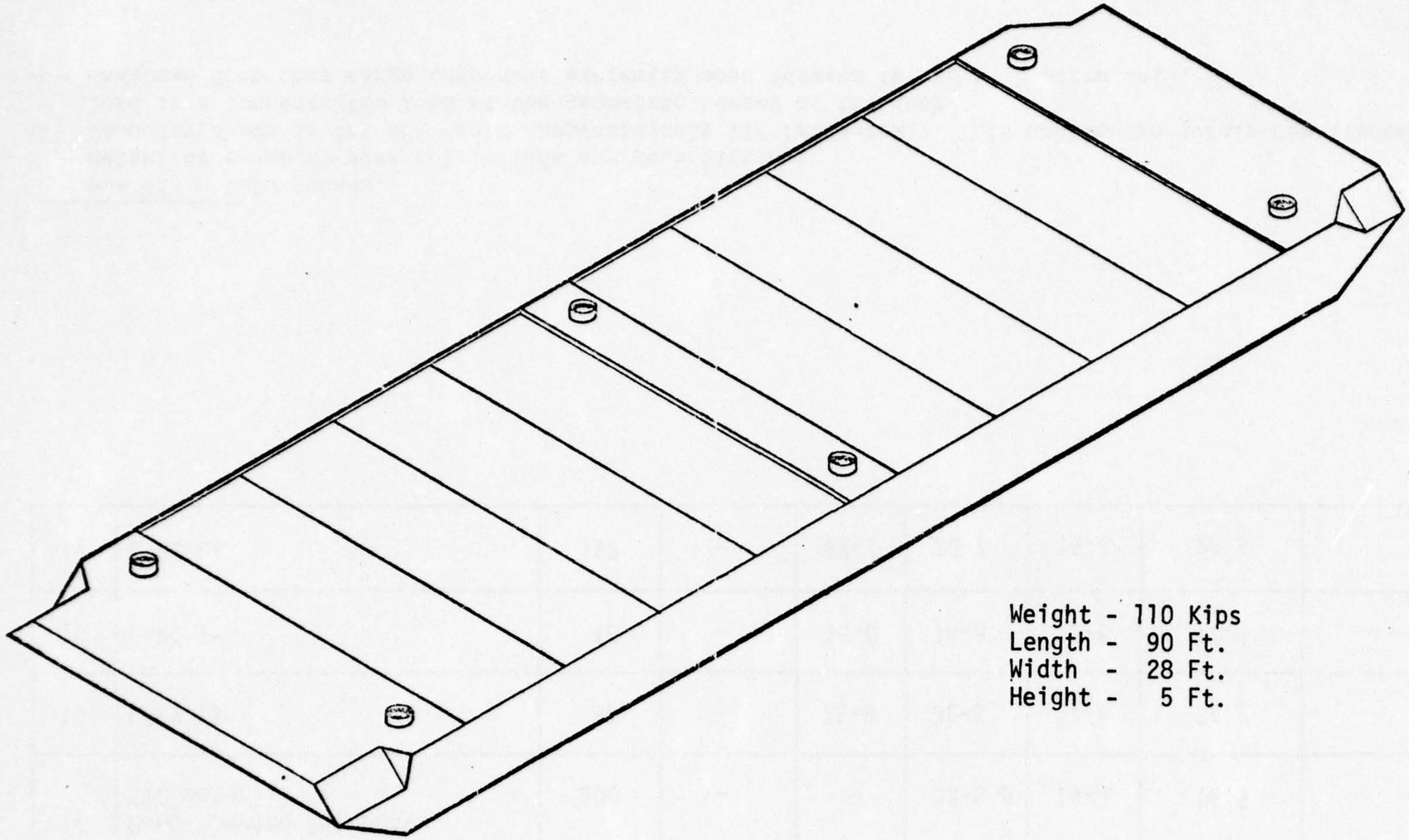
TABLE 3.1 CANDIDATE OUTSIZE CARGO COMPONENTS (Continued)

Item	Outsize Cargo Component			Weight (Kips)[1]	Load Capacity (Kips)[1]	Dimensions (Ft-In)			C.G. (Ft) Dist. From Fwd. End.[4]	Remarks
						Length	Width or Dia.	Height		
13	P & H 6250 Truck Crane	a	Bare Crane w/o Boom or Counter-weights	236	-	46-7	14-4	13-6	17.0	
		b	Bare Crane w/70' Boom & Counter-weights	353	-	113-5	14-4	13-6	17.0	
		c	Bare Crane w/o Boom or Counter-weights on 4x15 Std. Causeway	419	8	92-0	28-4	18-9	Variable	Note 3
		d	Bare Crane w/o Boom or Counter-weights on 4x15 Cause-way 6 Ext. Spudwells	426	1	92-0	28-4	18-9	Variable	Note 3
		e	Bare Crane w/o Boom or Counter-weights on AMMI Cause-way	346	299	90-0	28-0	18-6	Variable	Note 3

TABLE 3.1 CANDIDATE OUTSIZE CARGO COMPONENTS (Continued)

Item	Outsize Cargo Component	Weight (Kips)[1]	Load Capacity (Kips)[1]	Dimensions (Ft-In)			C.G. (Ft) Dist. From Fwd. End.[4]	Remarks
				Length	Width or Dia.	Height		
14	Mono-Mooring Pol Buoy (10 meter)	300	-	-	33-0 ø	14-0	16.5	
15	LACV (30)	57	-	75-8	32-6	24-8	36.2	
16	LARC XV	46	-	45-0	14-8	13-6	17.0	
17	LARC LX	197	-	62-7	26-7	15-4	28.5	

1 - One Kip = 1000 pounds.
2 - Height of causeway does not include any deck fittings.
3 - Capacity shown is for 48" draft (Approximately 12" freeboard). This assumes an evenly distributed load or a concentrated load at the geometric center of the deck.
4 - Measured from that cargo component extremity most forward in the LASH stern well.



Weight - 110 Kips
Length - 90 Ft.
Width - 28 Ft.
Height - 5 Ft.

Figure 3.1 AMMI Pontoon Causeway

Weight (Steel) - 134 Kips
Length - 73 Ft. - 8 in.
Width - 21 Ft. -.1 in.
Height - 15 Ft.

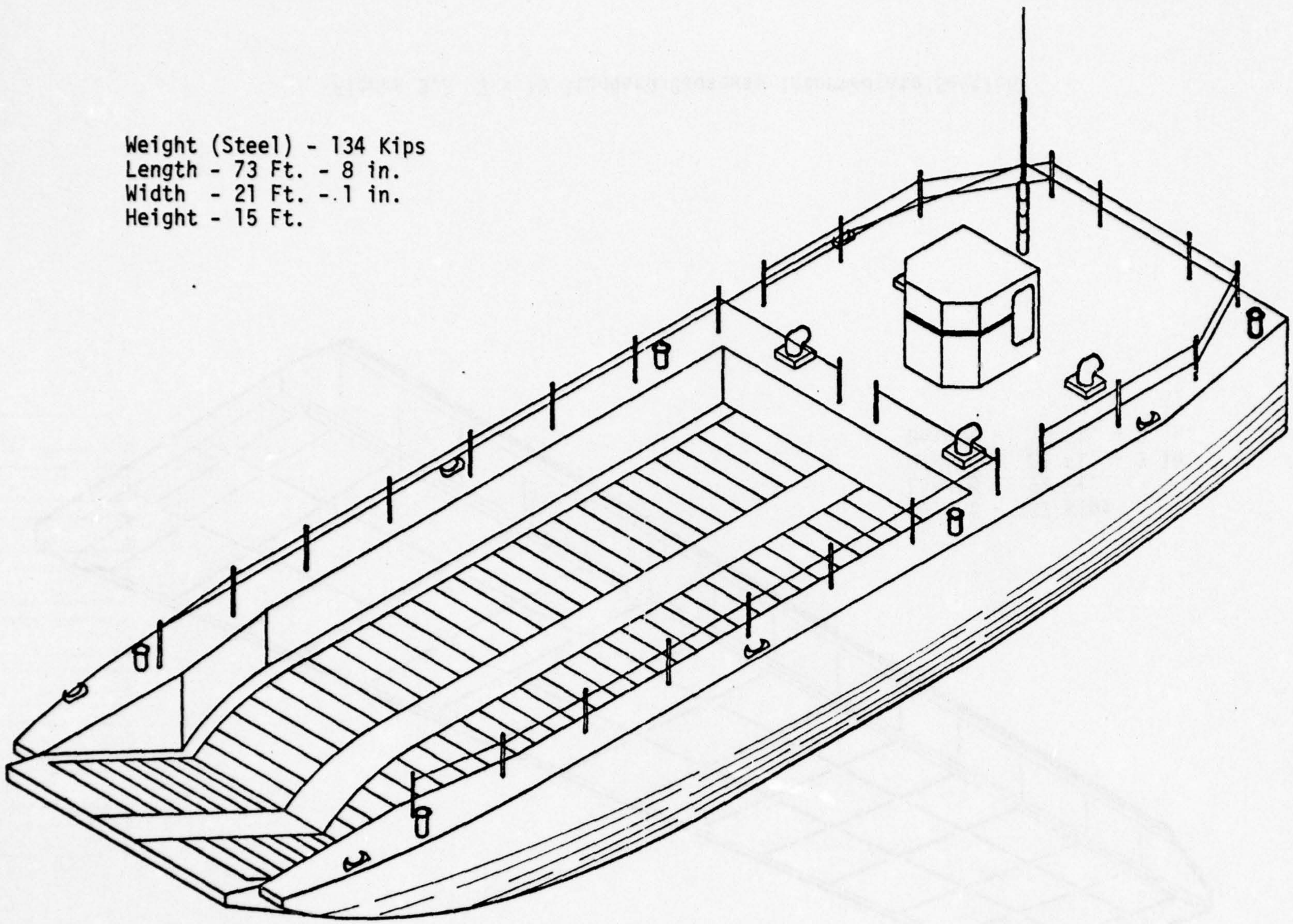
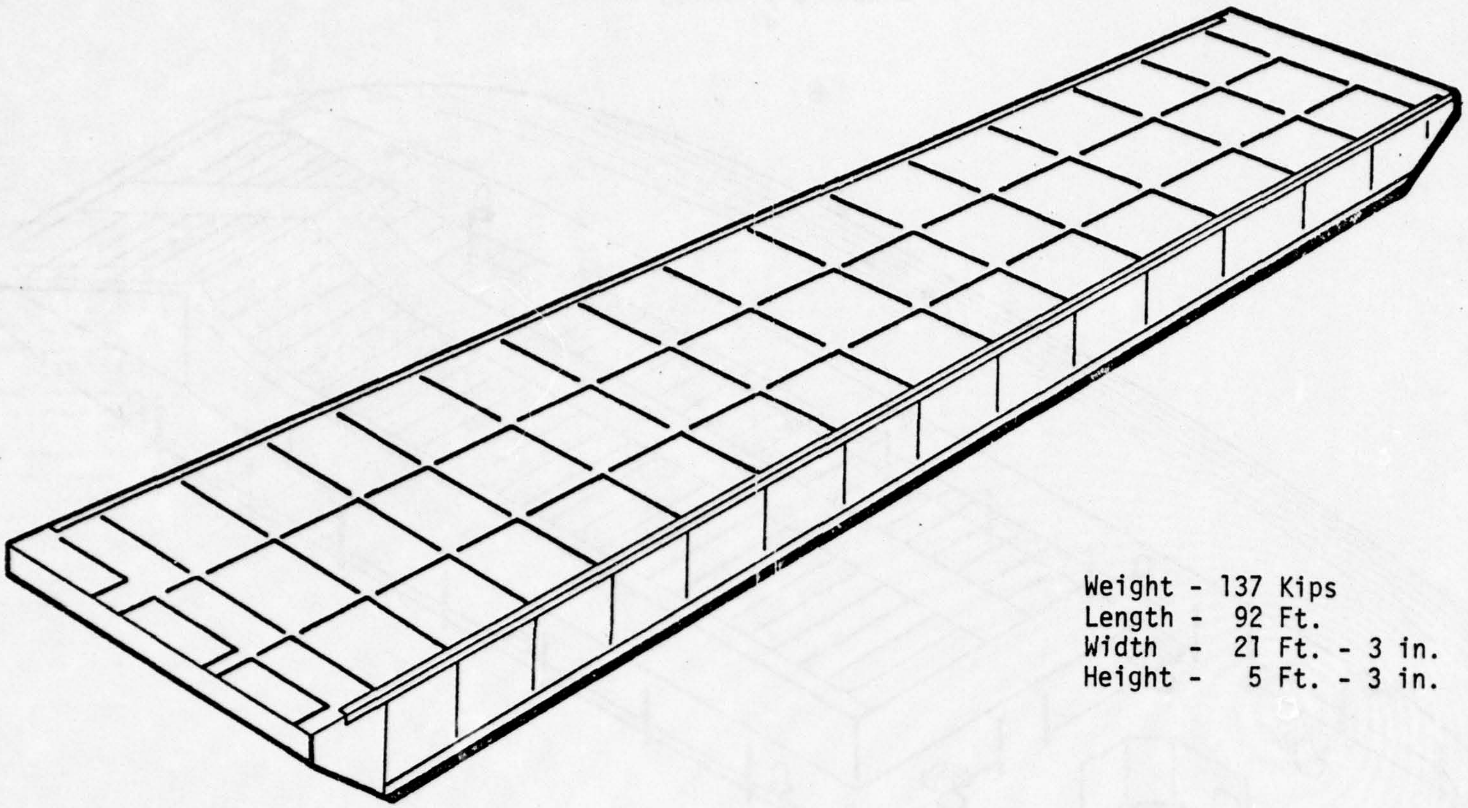
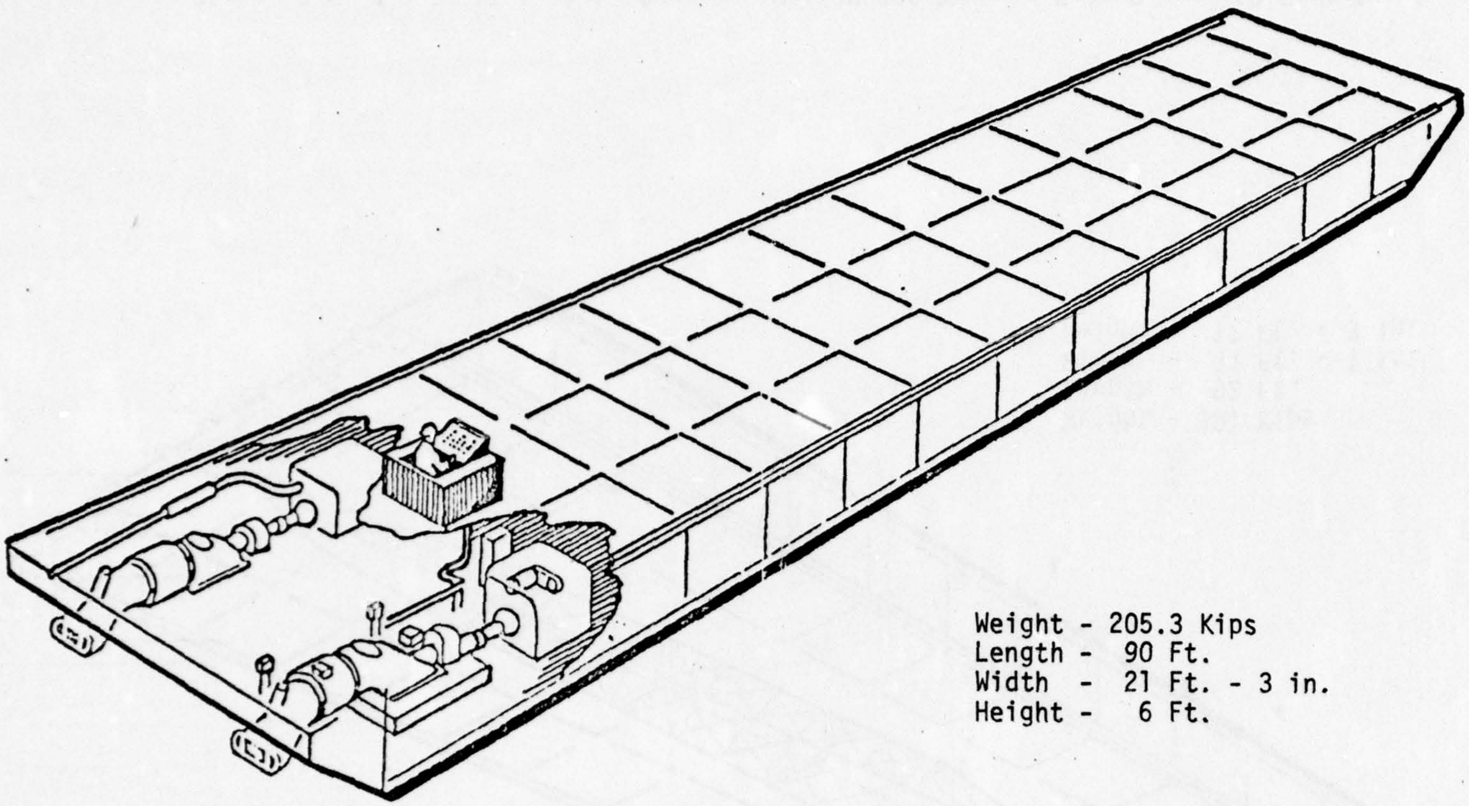


Figure 3.2 LCM-8



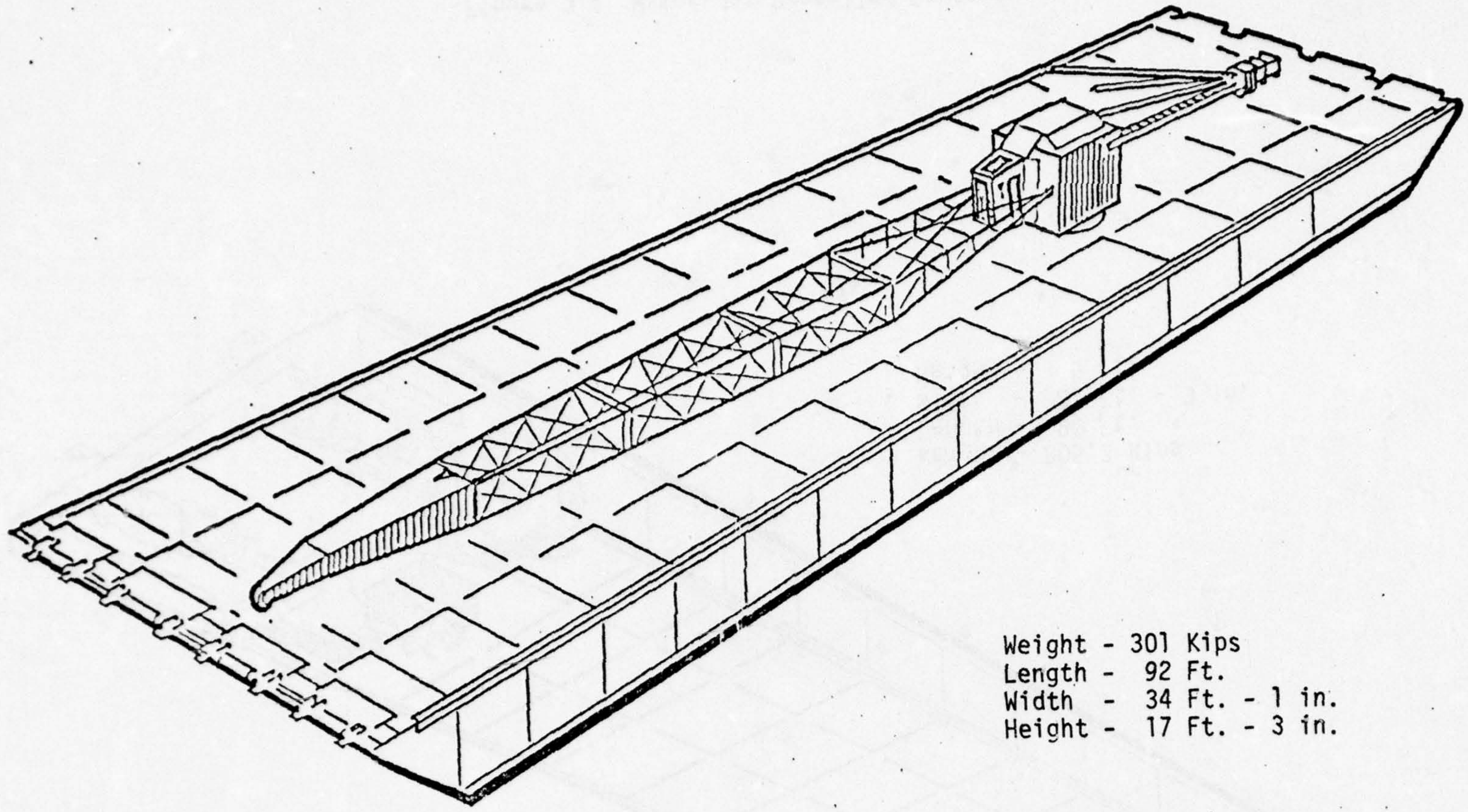
Weight - 137 Kips
Length - 92 Ft.
Width - 21 Ft. - 3 in.
Height - 5 Ft. - 3 in.

Figure 3.3 3 x 15 Standard Causeway Intermediate Section



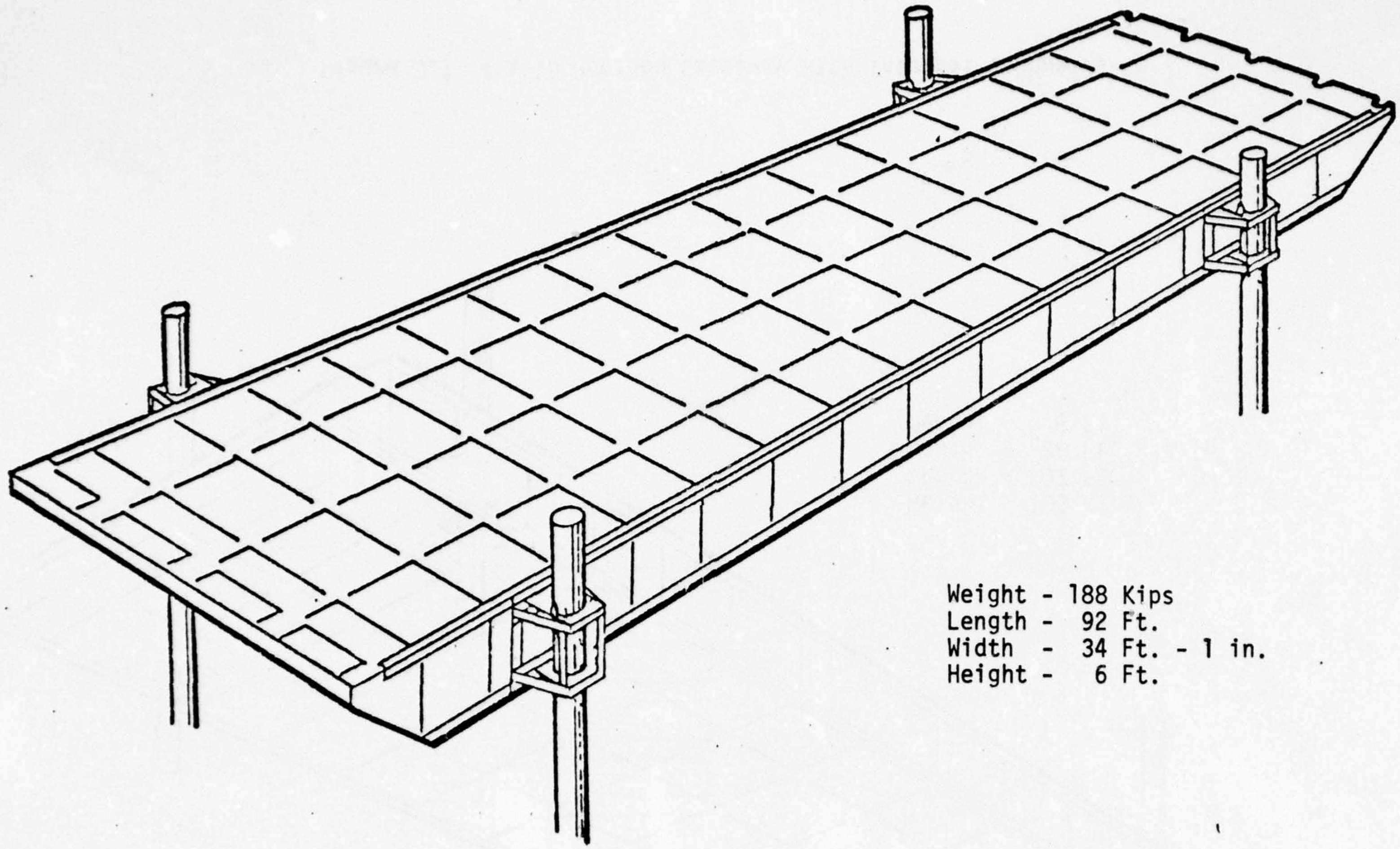
Weight - 205.3 Kips
Length - 90 Ft.
Width - 21 Ft. - 3 in.
Height - 6 Ft.

Figure 3.4 Water-Jet Propelled Causeway



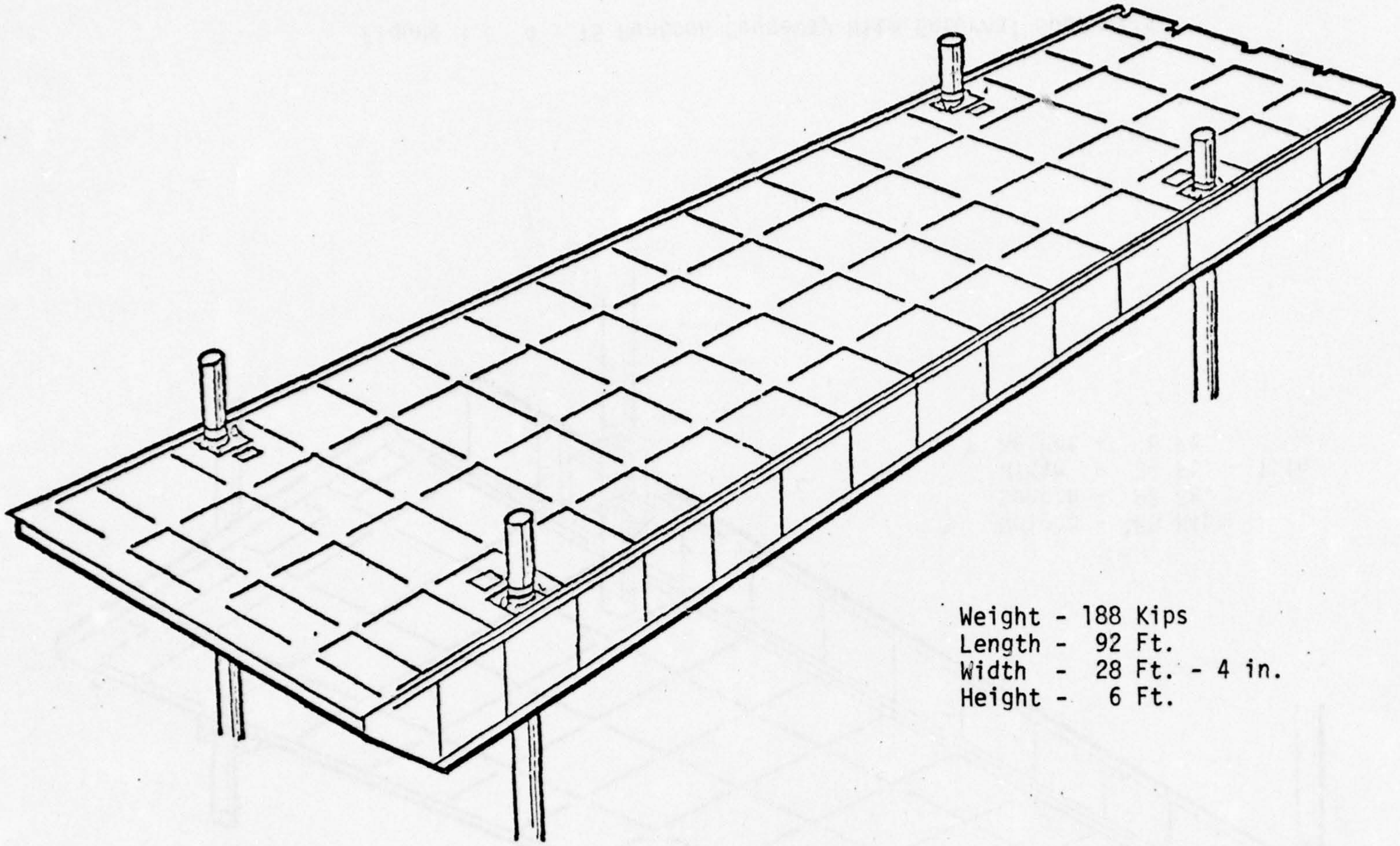
Weight - 301 Kips
Length - 92 Ft.
Width - 34 Ft. - 1 in.
Height - 17 Ft. - 3 in.

Figure 3.5 4 x 15 NL Pontoon Causeway With MK 100 Bucyrus Erie Crane (60 Foot Boom)



Weight - 188 Kips
Length - 92 Ft.
Width - 34 Ft. - 1 in.
Height - 6 Ft.

Figure 3.6 4 x 15 Pontoon Causeway With External Spudwells



Weight - 188 Kips
Length - 92 Ft.
Width - 28 Ft. - 4 in.
Height - 6 Ft.

Figure 3.7 4 x 15 Pontoon Causeway With Internal Spudwells

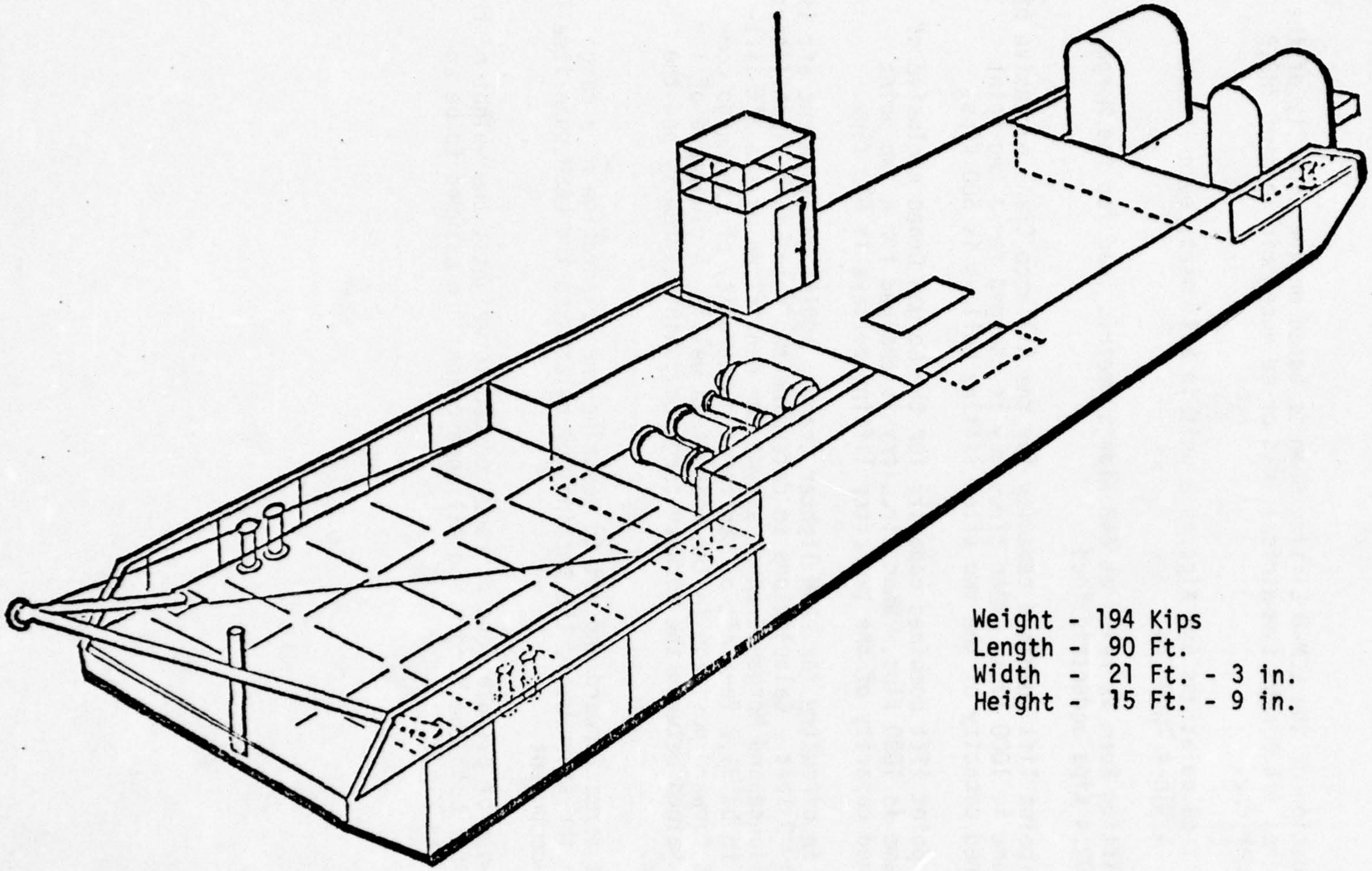


Figure 3.8 3 x 14 Warping Tug With Outboard Motor

TABLE 3.2

LIST OF FACTS AND ASSUMPTIONS

1. ABS certification of the LCM-8 Lifting Beam is based on the capacity of the Alliance Crane, 416.6 Kips symmetrical load or an eccentric load of 208.3 Kips at either end.

2. Load and lift calculations use Kips as a unit in all cases, even if not designated. 1 Kip = 1000 lbs.

3. The LCM-8 Lifting Beam is rated at 448 Kips symmetric load for the Morgan Crane and 302.4 Kips eccentric load.

4. Normal four point lift combined capacity for the Alliance Crane exclusive of the lift frame is 1000 Kips. When circuitry is changed for a two point lift, combined capacity of the two after lifting pulleys is 500 Kips.

5. Normal four point lift combined capacity for the Morgan Crane exclusive of the lift frame is 1020 Kips. When circuitry is changed for a two point lift, combined capacity of the two after lifting pulleys is 510 Kips.

6. With change in circuitry for LASH lighter cranes, additional movement aft is approximately 3 feet. Calculations to determine two point lift capabilities for both Alliance and Morgan Cranes, assume the centerline of the aft lifting sockets to be 31.7 feet aft of the forward extremity of the cargo component (most forward position in the LASH stern well). A clearance of 1 foot is maintained between the forward cargo component extremity and the LASH transom.

7. In using the terms forward and aft to describe the orientation of a cargo component in the stern well, the terminology relates to the LASH ship itself and not the component.

8. For the purpose of calculations of required counterweights, the weight of the load frames for both the Morgan and Alliance cranes are assumed to be approximately 144 Kips.

4. PROPOSED LIFTING TECHNIQUE CAPABILITIES

Seven outsize cargo lifting and discharging concepts are described below. A general outsize cargo lifting/discharging system is desired. However, the seven concepts will be evaluated as to their ability to handle the outsize cargo described in Table 3.1. Because of the physical differences in the Morgan and Alliance lighter lift frames it is necessary to evaluate each separately. Each lifting concept will be examined for physical and calculated capability and functional operability in a military environment.

Based on the evaluation of the seven proposed concepts, lifting cargo equipment will be defined that has the capability of loading and off-loading Navy elevated causeway and port facility components in a sea state 3 and post assault environment.

The practicality of changing the lighter crane circuitry on the C-8 LASH Ships will be discussed in later paragraphs. In addition, the feasibility of modifying existing hardware compatible with the ship's peacetime mission or the addition of supplementary lifting equipment to accommodate the LAPS mission will be determined. The LAPS mission requirements include cargo components larger than the 61'-1" x 31'-2" lighter barge. The LASH lighter has a maximum gross weight of 1,000 Kips. In general, the causeway components weigh between 100 Kips and 300 Kips and have a longitudinal dimension of about 90 feet.

Proposed outsize cargo lifting and discharge subsystems to be evaluated are:

1. Use of the lighter gantry crane "as is". (Section 4.1)
2. Use of the LCM-8 lifting beams. (Section 4.2)
3. Use of the LCM-8 lifting beams with counterweights and compression members. (Section 4.3)

4. Use of a new beam or beams with integral racks and independently operated worm or pinion operated lift points. (Section 4.4)

5. Use of a cantilever lift frame to replace the LCM-8 lift beam, with racks, independently operated worm or pinion driven lift points. (Section 4.5).

6. Use of a rotating, non-elevating but telescoping jib boom and winch mounted on top of the lighter gantry. (Section 4.6)

7. Use of a pedestal crane mounted on top of the lighter gantry. (Section 4.7)

4.1 Use of Lighter Cranes "As Is"

As stated previously, there are physical differences in the Alliance and Morgan lighter gantry crane lifting frames which are significant to the LAPS mission. The properties of each are discussed separately below. The Alliance Crane has to be further divided into two cases. The eleven C-8 LASH Ships all have Alliance lighter cranes and will be referred to as 'unmodified'. The three Waterman C-9 LASH Ship Alliance lighter cranes have had modifications allowing the use of the LCM-8 lift beam. (The LCM-8 lift beam is described in Section 4.2). Basically the lighter crane modifications automatically defeat sensors and limit switches which assure that a lighter has its center of gravity within tolerance and that the forward lighter lifting sockets are engaged. Additionally, the modification defeats the 'Gantry Aft Final Stop' limit switch. This allows the lighter gantry crane to travel farther aft allowing additional clearance between the outsize cargo and the transom of the ship. The aft lighter frame guides mounted on the crane overhang must be removed (unbolted) and temporary aft lighter frame guides mounted further aft. Refer to Figure 4.1.

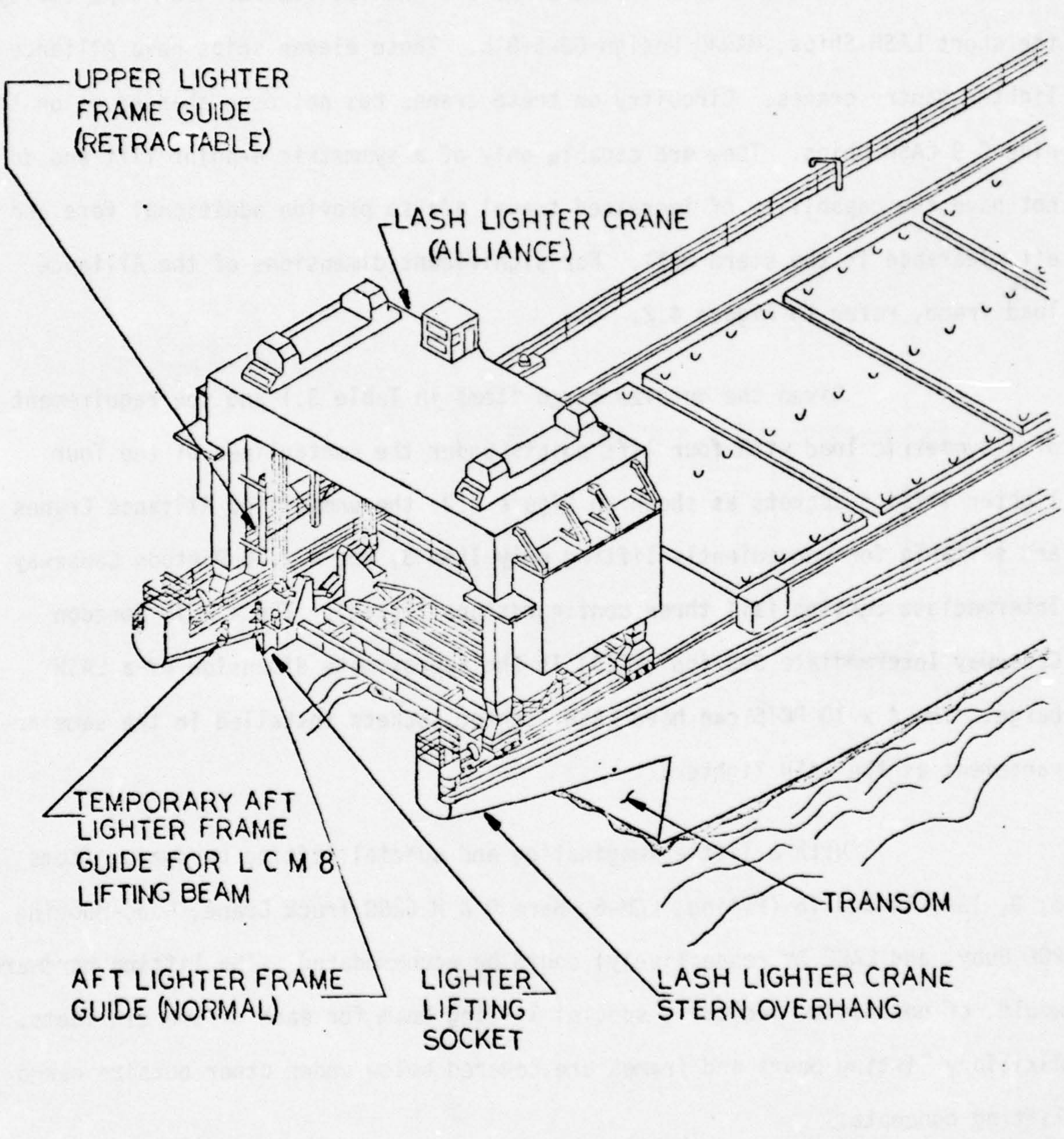


Figure 4.1 LASH Lighter Frame Guide Installation

4.1.1 Unmodified Alliance Cranes

The Prudential Grace Lines and the Pacific Far East Line employ the short LASH Ships, MARAD Design C8-S-81b. These eleven ships have Alliance lighter gantry cranes. Circuitry on these cranes has not been changed as on the nine C-9 LASH Ships. They are capable only of a symmetric 4-point lift and do not have the capability of increased travel aft to provide additional fore and aft clearance in the stern well. For significant dimensions of the Alliance load frame, refer to Figure 4.2.

Given the outsize cargo items in Table 3.1 and the requirement of a symmetric load with four lift points under the centerlines of the four lighter lifting sockets as shown in Figure 4.2; the unmodified Alliance Cranes are suitable for conveniently lifting only Item 3, the 4 x 10 Pontoon Causeway Intermediate Section (all three configurations listed). The 4 x 10 Pontoon Causeway Intermediate Section (PCIS) is the approximate dimension of a LASH barge. The 4 x 10 PCIS can have LASH lighter sockets installed in the same arrangement as the LASH lighter.

With a little imagination and special lifting hardware, Items 5, 9, 13a, 14 and 16 (Piling, LCM-6, Bare P & H 6250 Truck Crane, Mono-Mooring POL Buoy, and LARC XV respectively) could be accommodated. The lifting hardware would, of necessity, include a special lifting beam for each of the six items. Auxiliary lifting beams and frames are covered below under other outsize cargo lifting concepts.

The unmodified Alliance cranes are not suitable for lifting LAPS outsize cargo without use of special lift beams.

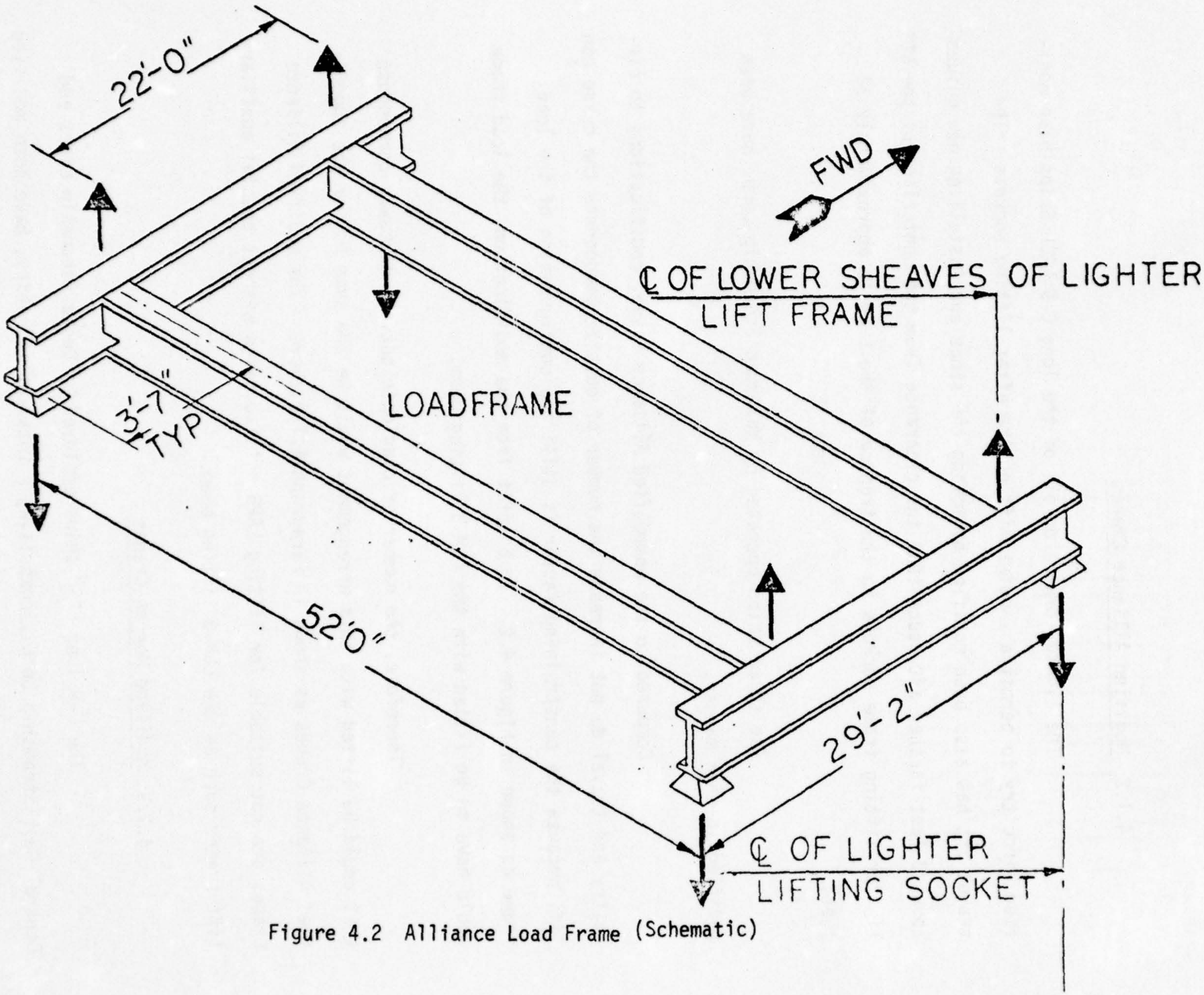


Figure 4.2 Alliance Load Frame (Schematic)

4.1.2 Modified Alliance Cranes

The lighter cranes on all of the long C-9 LASH Ships have modified circuitry to permit a 2-point lift on the after lifting sockets. The travel aft has also been modified by moving the stops and installing new guides about 3 feet farther aft, such that the clearance from the centerline of the aft lighter lifting frame sockets to the transom of the LASH is approximately 32 feet.

The three ships operated by Waterman Steamship Corp. have been modified in this manner.

Compared to the unmodified Alliance Crane, modifications to circuitry and travel do not increase the number of outsize components the crane can lift because the constraining factor is still the configuration of the load frame as shown in Figure 4.2. To benefit from the modification, the load frame would have to be fitted with the LCM-8 lifting beam.

Therefore, the number of candidate outsize causeway components that could be lifted with this arrangement would be the same as for the unmodified Alliance Cranes as shown in Paragraph 4.1.1 above. The modified Alliance Cranes are not suitable for lifting LAPS outsize cargo without special auxiliary lift frames such as the LCM-8 lifting beam.

4.1.3 Modified Morgan Cranes

The C-9 long LASH ships employed by Delta Steamship Lines and Central Gulf Steamship Corp., comprising a total of (6) ships, have been modified in their circuitry to provide approximately 3 feet further movement aft and a 2-point lift using the after lifting points.

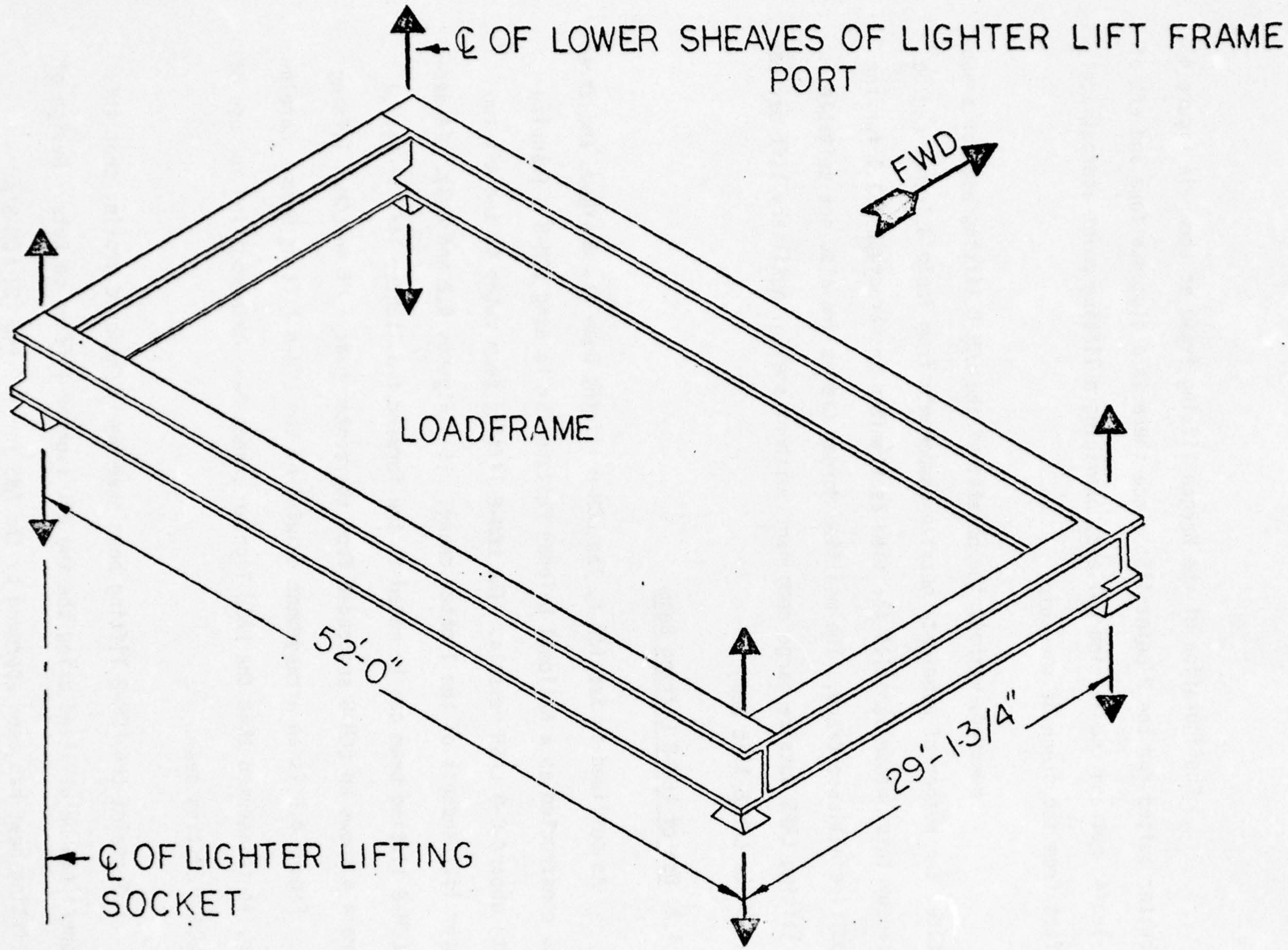
Configuration of the Morgan lifting frame as shown in Figure 4.3 is better suited for the 2-point lift since there is a distance fore and aft of 29'-1-3/4" between the lifting pulleys, providing a lifting point approximately 32 feet from the stern of the ship.

However, without the benefit of the LCM-8 lifting beam or a substitute, the number of candidate outsize components from Table 3.1 that can be lifted by this method is still the same as itemized in Paragraph 4.1.1 for the unmodified Alliance Crane. The modified Morgan Cranes are also not suitable for lifting LAPS outsize cargo components without special auxiliary lift devices such as the LCM-8 lift beam.

4.2 Use of LCM-8 Lifting Beam

As outlined in Section 1, the LCM-8 lifting beam was designed and three units constructed as a National Defense Feature for loading LCM-8's (Landing Craft) aboard C-9 LASH vessels. The LCM-8 lifting beam mates to the aft two lighter lift sockets of the lighter crane. (See Figures 4.2 and 4.3). (A second LCM-8 lifting beam can be mated to the forward two lighter lift sockets.) Figure 4.4 shows an LCM-8 suspended from the center padeye of an LCM-8 lifting beam. Figure 4.5 is an arrangement drawing of the LCM-8 lifting beam. Hereinafter, it is assumed that the LASH lighter cranes have been modified for use of the LCM-8 lifting beam.

Tests of the LCM-8 lifting beam have been conducted proving that this component can be utilized using the two aft lighter lifting sockets. Design of the lifting beam has been approved by the ABS for lifting (2) LCM-8's



4.3 Morgan Load Frame (Schematic)

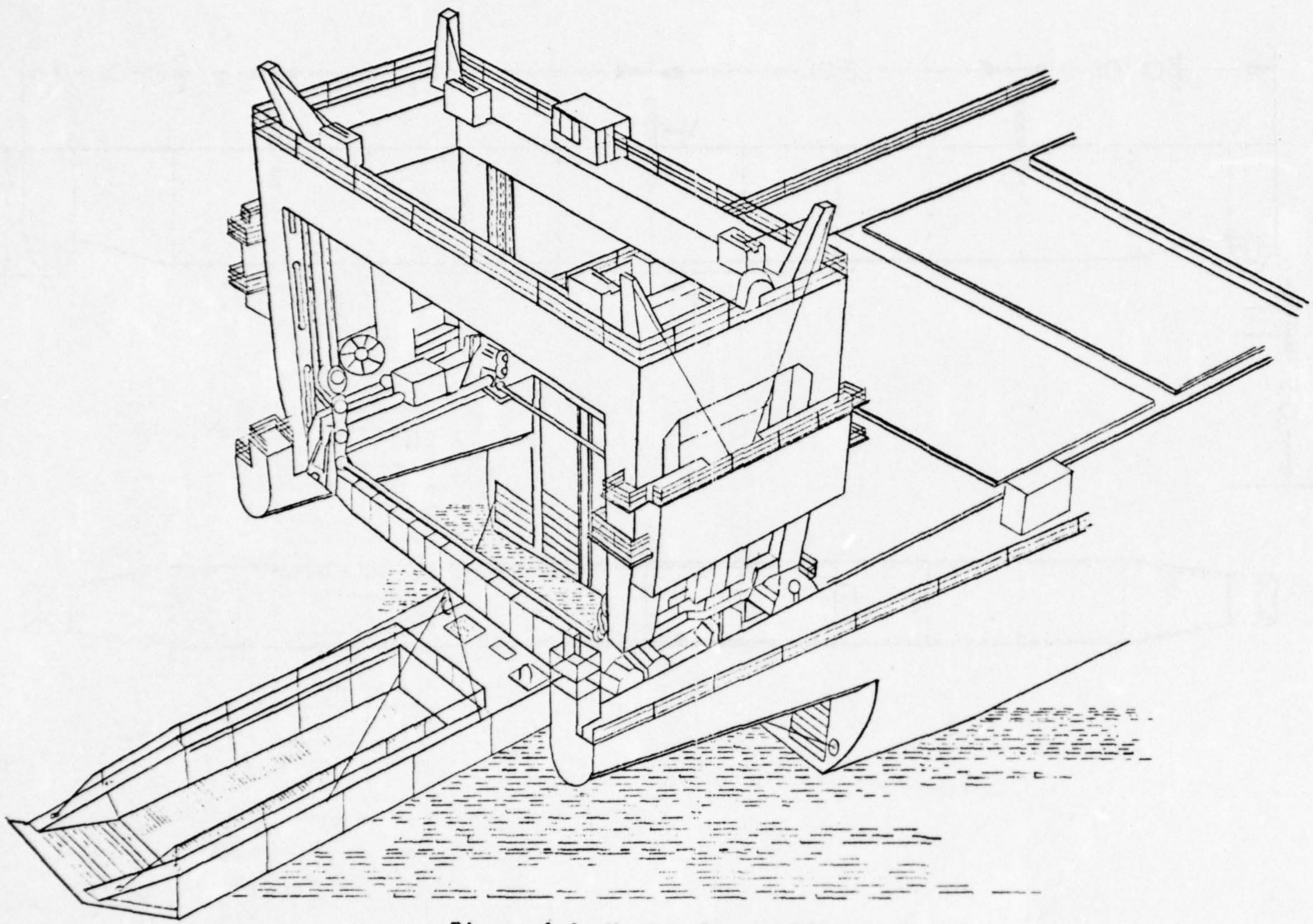


Figure 4.4 Morgan Crane Lifting LCM-8

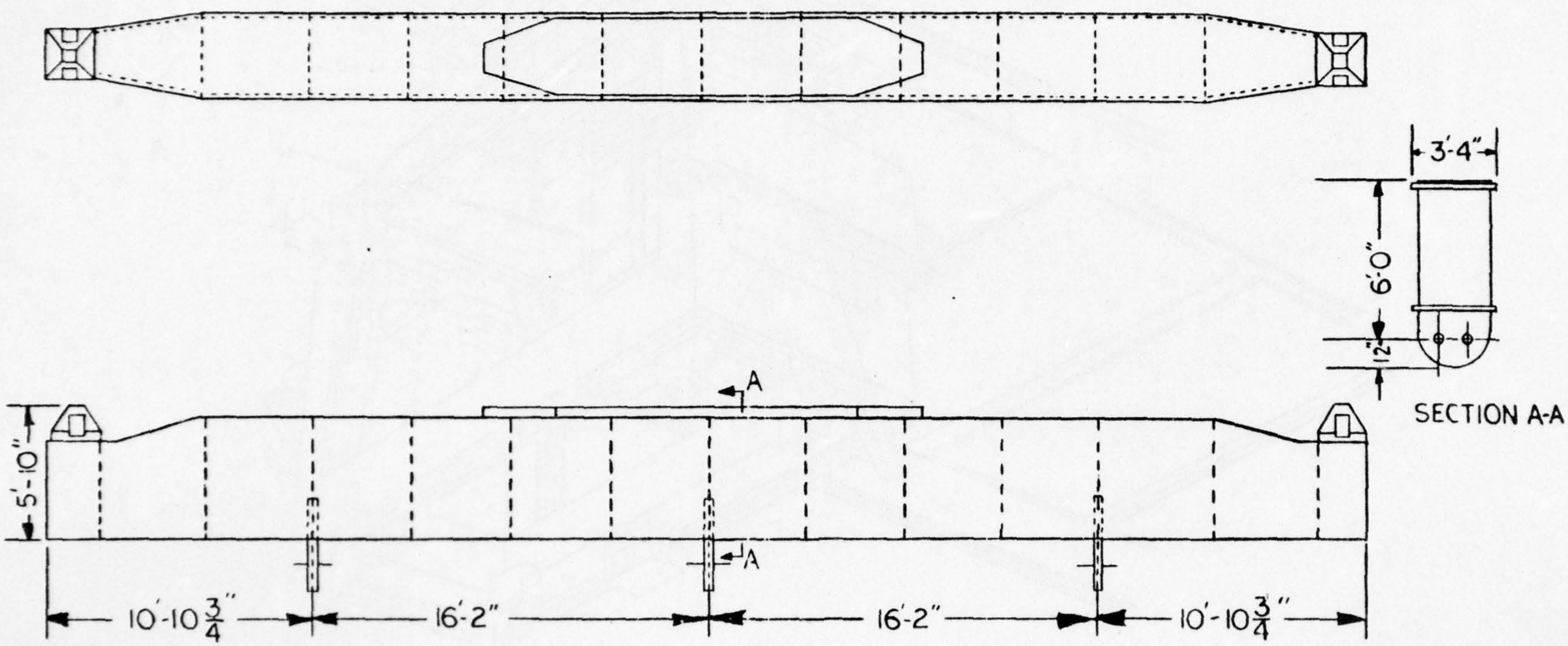


Figure 4.5 LCM-8 Lifting Beam

simultaneously. Maximum rating of the beams is 416.6 Kips symmetrical load or 208.3 Kips at either end. Lifting eyes are provided port and starboard 10'-10-3/4" from the lifting points and one is provided on the centerline. Refer to Figure 4.5. This arrangement does not permit the shifting of the lifting points to position the LCM-8's on the deck of the LASH.

Table 4.1 repeats the items in Table 3.1. Each component is evaluated on its ability to be lifted by an LCM-8 lift beam with no external counterweight. In some cases a second LCM-8 lift beam is required on the forward lighter lifting sockets to provide a lifting force. Except as noted, no consideration is given to how the component will float once in the water. Items 12b, 13c and 13d are so marginal they were ruled out because even a small shift in the center of gravity (C.G.) from the C.G. of the causeway component would be disastrous. A minimum distance of one foot between the component and stern of the ship was maintained to calculate the suitability of a lift.

Unless otherwise noted, all items are lifted with their centerline parallel to that of the ship on the center padeye of the LCM-8 lift beam. Some components can be lifted from any of the padeyes or any pair of padeyes but the data is not presented here. The significant point is whether a component can be lifted not how many configurations by which it can be lifted. However, by inspection, any component that can be lifted which weighs less than 208 Kips and is less than 28 feet wide can be lifted from any of the three padeyes on the LCM-8 lifting beam. Calculations supporting the results tabulated in Table 4.1 are included in Appendix "A".

Vertical clearance is a potential problem for rigging but none of the items in Table 4.1 are too high to fit under the lighter crane with the LCM-8

TABLE 4.1 LCM-8 LIFT BEAM OUTSIZE CARGO COMPONENTS DISCHARGE CAPABILITY
(No Counterweights or Compression Members)

Item	Outsize Cargo Component			Weight (Kips)$_1$	Dimensions (Ft-In) Length	Dimensions (Ft-In) Width or Dia.	Remarks
1	3x15 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	137	92-0	21-3	The C.G. of component lies outside acceptable range. Lift is impossible with either Alliance or Morgan Cranes.
		b	4 Internal Spudwells	142	92-0	21-3	
		c	4 External Spudwells	142	92-0	27-0	
		d	6 Internal Spudwells	144	92-0	21-3	
		e	6 External Spudwells	144	92-0	27-0	
2	4x15 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	183	92-0	28-4	
		b	4 Internal Spudwells	188	92-0	28-4	
		c	4 External Spudwells	188	92-0	34-1	
		d	6 Internal Spudwells	190	92-0	28-4	
		e	6 External Spudwells	190	92-0	34-1	
3	4x10 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	122	61-1	28-4	Both cranes satisfactory for either orientation of load using either one or two LCM-8 lift beams.
		b	4 Internal Spudwells	127	61-1	28-4	
		c	4 External Spudwells	127	61-1	34-1	
4	AMMI Pontoon Causeway			110	90-0	28-0	See Remarks for Items 1 and 2 above.

TABLE 4.1 LCM-8 LIFT BEAM OUTSIZE CARGO COMPONENTS DISCHARGE CAPABILITY
(No Counterweights or Compression Members) (Continued)

Item	Outsize Cargo Component			Weight (Kips)[1]	Dimensions (Ft-In) Length	Dimensions (Ft-In) Width or Dia.	Remarks
5	Piling	a	Single	6.2	60-0	1-8 ø	Lift athwartships under beam. Both Alliance and Morgan Cranes are satisfactory.
		b	Bundle of 3	18.7	60-0	3-4	
6	Water-Jet Propelled Causeway			205.3	90-0	21-3	The C.G. of component lies outside acceptable range. Lift is impossible.
7	3 x 14 Pontoon Warping Tug (P-Series)			194	90-0	21-3	
8	Side Loadable Warping Tug	a	w/Outboard Propulsion	227	91-0	21-3	
		b	w/Water-Jet Propulsion	230	91-8	21-3	
9	LCM-6			56	56-2	14-1	Lift one craft from any beam padeye or one on each outboard padeye. Both Morgan and Alliance Cranes are satisfactory. LCM-6 can also be lifted athwartships by both cranes.
10	LCM-8	a	Aluminum Hull	115	74-3	21-1	
		b	Steel Hull	134	73-8	21-1	

TABLE 4.1 LCM-8 LIFT BEAM OUTSIZE CARGO COMPONENTS DISCHARGE CAPABILITY (No Counterweights or Compression Members) (Continued)

Item	Outsize Cargo Component			Weight (Kips)1	Dimensions (Ft-In)		Remarks
					Length	Width or Dia.	
11	Bucyrus-Erie MK-100 Marine Crane w/60' Boom	a	Bare Crane	111	92-0	17-10	Both cranes satisfactory w/load C.G. under beam.
		b	On 3x15 Causeway w/6 Ext. Spudwells	255	92-0	27-0	Both cranes suitable w/MK-100 C.G. about 13' from forward end of causeway.
		c	On 4x15 Causeway w/6 Ext. Spudwells	301	92-0	34-1	Both cranes unsatisfactory. C.G. too far aft.
	(A-Frame Lowered)	d	On 4x10 Causeway w/4 Ext. Spudwells	238	92-0	34-1	Both cranes satisfactory using one or two LCM-8 lift beams. Causeway in either orientation satisfactory.
		e	On AMMI Causeway	221	92-0	28-0	Both cranes satisfactory w/C.G. of MK-100 approximately 18.6' from fwd. end of causeway.
12	P & H 9125 Truck Crane w/60' Boom	a	Bare Crane	190	94-0	11-1	Both cranes satisfactory w/C.G. under beam.
		b	On 3x15 Std. Causeway	327	94-0	27-0	Because of trim the crane must remain over C.G. of causeway. Under this condition both cranes unsatisfactory.
		c	On 4x15 Causeway w/6 Ext. Spudwells	380	94-0	34-1	Both cranes satisfactory w/C.G. of crane approximately 17.5' from forward end of causeway.
		d	On AMMI Causeway	300	94-0	28-0	Both cranes satisfactory w/C.G. of P & H 9125 approximately 24' from forward end of causeway.

TABLE 4.1 LCM-8 LIFT BEAM OUTSIZE CARGO COMPONENTS DISCHARGE CAPABILITY (No Counterweights or Compression Members) (Continued)

Item	Outsize Cargo Component			Weight $(\text{Kips})_1$	Dimensions (Ft-In) Length	Dimensions (Ft-In) Width or Dia.	Remarks
13	P & H 6250 Truck Crane	a	Bare Crane w/o Boom or Counter-weights	236	46-7	14-4	Both cranes satisfactory w/load C.G. under beam.
		b	Bare Crane w/70' Boom & Counter-weights	353	113-5	14-4	
		c	Bare Crane w/o Boom or Counter-weights on 4x15 Std. Causeway	419	92-0	28-4	Due to trim considerations the C.G. of P & H 6250 crane must remain over C.G. of causeway. Under this condition, the lift is impossible with either the Alliance or Morgan Cranes.
		d	Bare Crane w/o Boom or Counter-weights on 4x15 Cause-way 6 Ext. Spudwells	426	92-0	28-4	
		e	Bare Crane w/o Boom or Counter-weights on AMMI Cause-way	346	90-0	28-0	Both Alliance and Morgan Cranes are satisfactory with P & H 6250 C.G. approximately 25.6 ft. from forward end of causeway.

TABLE 4.1 LCM-8 LIFT BEAM OUTSIZE CARGO COMPONENTS DISCHARGE CAPABILITY
(No Counterweights or Compression Members) (Continued)

Item	Outsize Cargo Component	Weight (Kips)1	Dimensions (Ft-In)		Remarks
			Length	Width or Dia.	
14	Mono-Mooring Pol Buoy (10 meter)	300	-	33-0 ø	Both cranes satisfactory w/C.G. under beam.
15	LACV 30	57	75-8	32-6	The C.G. of component lies outside acceptable range. Lift is impossible w/o small counterweight.
16	LARC XV	46	45-0	14-8	Both cranes satisfactory w/C.G. under beam.
17	LARC LX	197	62-7	26-7	Both cranes satisfactory w/C.G. under beam.

1 - One Kip = 1000 pounds.

lift beam in the lighter frame while the cargo component is on deck (i.e., at the level of the highest obstruction on the hatch covers.)

An example of the significance of vertical height restrictions is the LCM-8. The LCM-8's have standard slings and are outfitted to be lifted from a single point as shown in Figure 4.6. The vertical height from the padeyes on the LCM-8 to the top of the sling is 13'-6". This is, however, in excess of the available space.

Required vertical space is as follows:

Depth of Lifting Beam to Padeye	5'-2"	
Boat Chocks	2'-0"	approx.
Elevation of LCM-8 Padeyes Above Keel	10'-3"	
Clearance Above Chocks	1'-0"	
Total	18'-5"	

Subtracting 18'-5" from 28'-11-1/2" (clearance between lighter frame and hatch cover projections) leaves 10'-6-1/2" vertical distance for the rigging[1].

Accordingly, the vertical height of LCM-8 rigging to be used with the LCM-8 lifting beam should be changed from 13'-6" to 10'-6-1/2". The standard LCM-8 slings are not suitable. Rather than shortening the slings and thereby increasing their size and increasing the loading at the padeyes on the LCM-8, it may be more feasible to build a small rectangular frame to attach to the LCM-8 lift beam and connect short slings to the four corners which attach to the four LCM-8 lifting padeyes. The frame can be constructed of a size to have the slings maintain the same angle as the current sling. No modifications of the LCM-8's will be required.

(1) The Alliance Crane has 4 inches more clearance than Morgan. Refer to Figure 4.6.1.

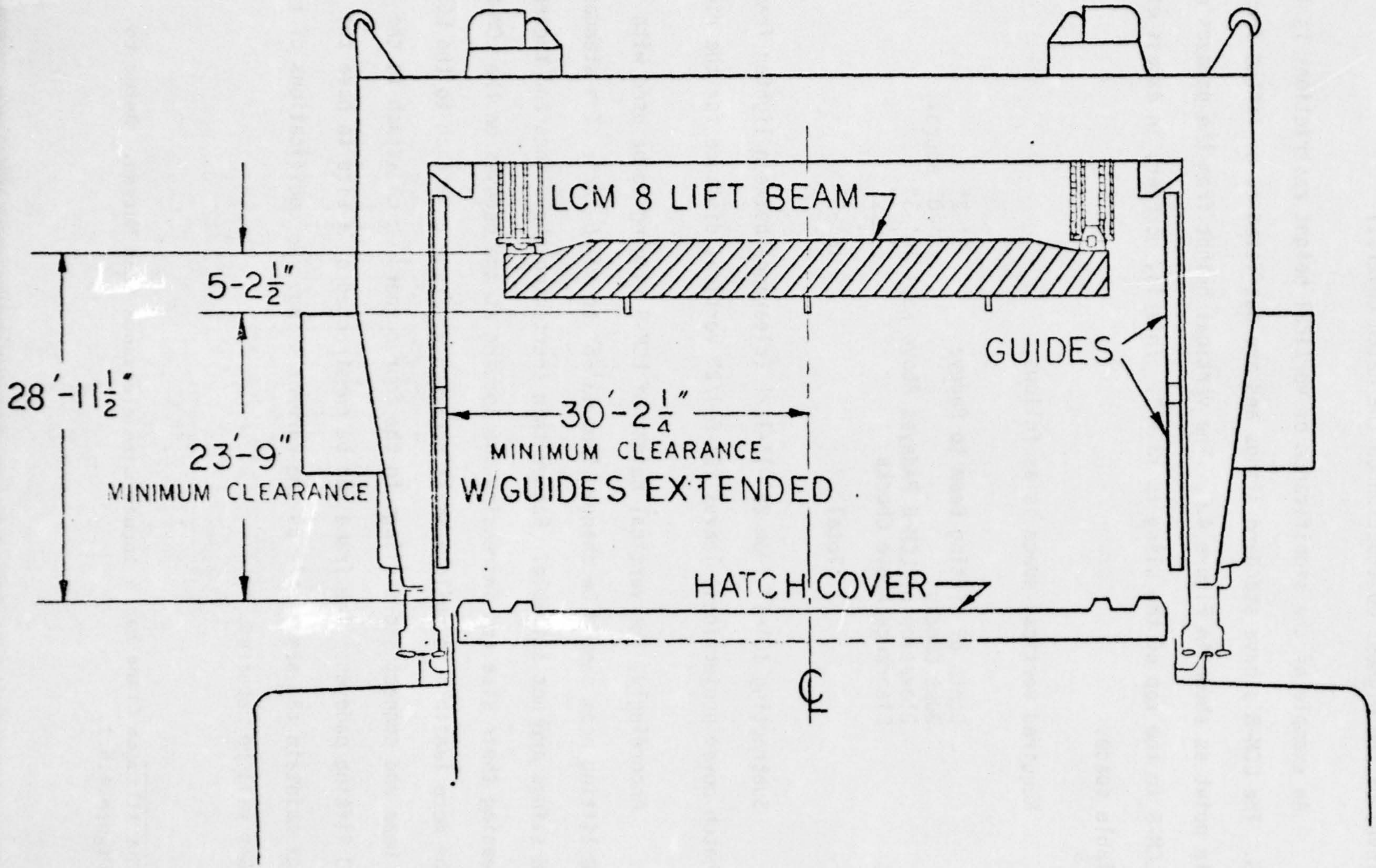


Figure 4.6 Morgan Crane Clearance Diagram with LCM-8 Lifting Beam

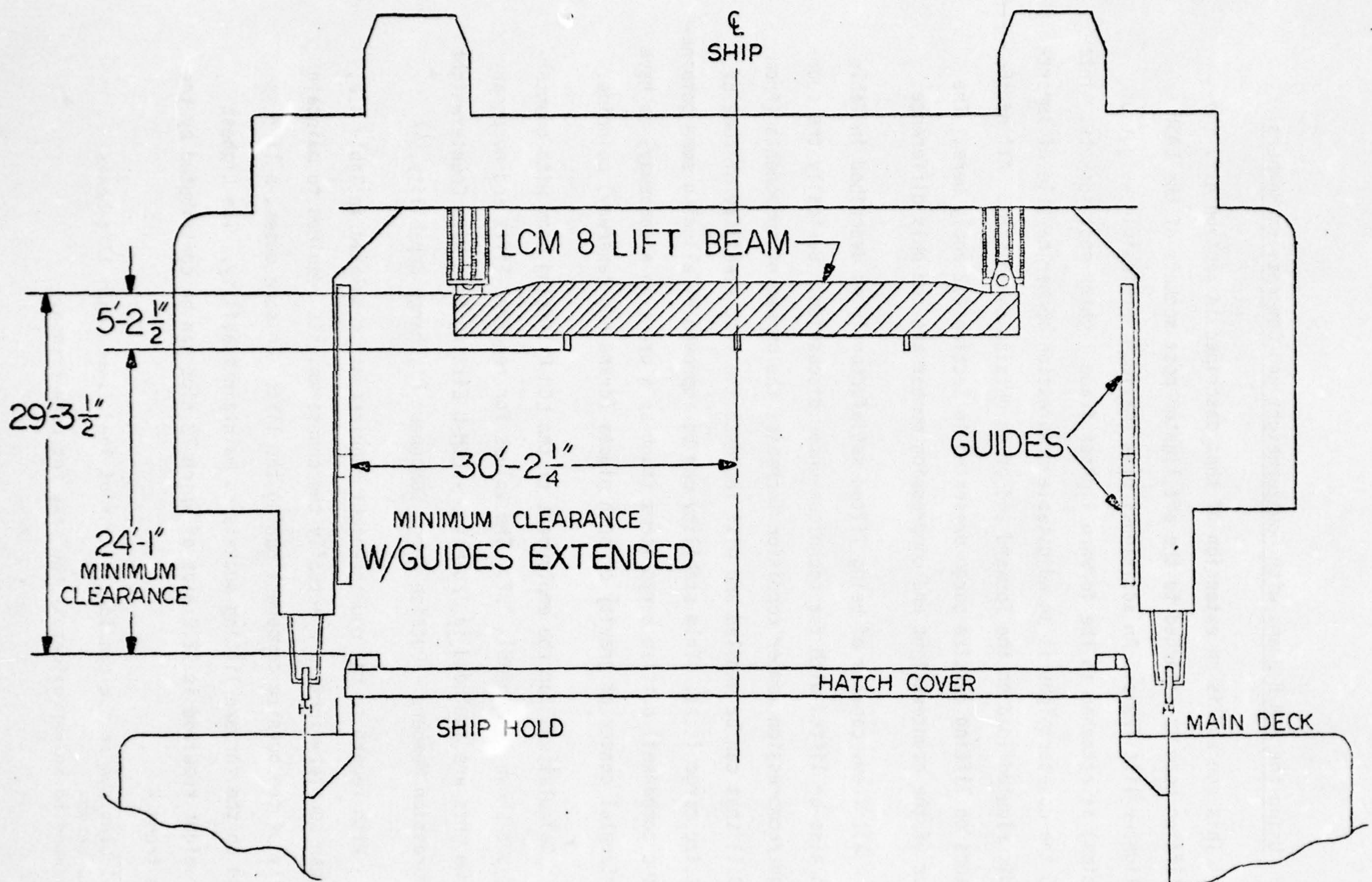


Figure 4.6.1 Alliance Crane Clearance Diagram With LCM-8 Lifting Beam

4.3 Using the LCM-8 Beams with Counterweight and Compression Members

This concept is an extension of that described in Section 4.2. An LCM-8 lifting beam is attached to the aft lighter post sockets of the LASH crane lighter lift frame. An additional beam (maximum permissible weight of 416.6 Kips) is attached to the forward lighter frame lighter post sockets. Integral to the counterweight is an adjustable compression member capable of imparting a distributed load on the forward end of an outsize cargo item. All of the conditions on lifting outsize cargo presented in Section 4.2 apply here. The addition of the counterweight and compression member are the only difference.

All items capable of being lifted satisfactorily as described in Table 4.1 can also be lifted with the technique under discussion. Basically the counterweight/compression member condition increases the number of components (from Table 3.1) that can be handled and will increase the lift stability of some of the outsize cargo items. Trim stability can be improved by allowing some combination (two component) outsize cargo items (such as a crane on a causeway) to have the horizontal center of gravity of both pieces (crane and causeway) coincide.

Calculations for the employment of the LCM-8 lifting beam with counterweights are shown in Appendix "B". The values for required lifts and necessary counterweights are included in Table 4.2 - LCM-8 Lifting Beam With Counterweight and Compression Members - Outsize Cargo Component Discharge Capability.(1)

With regard to the counterweight requirements tabulated in Table 4.2, the Morgan counterweights are actually the counterweights required to maintain stability of the outsize component during the lift. In some cases, a lift is required on the forward lifting sockets to maintain stability. The highest counterweight required is 92.9 Kips of which 72 Kips can be contributed by the lifting frame.2

(1) Calculations do not consider weight of load frame, only lift beams and cargo.
(2) Assumed to be approximately the same for both cranes.

TABLE 4.2 LCM-8 LIFTING BEAM WITH COUNTERWEIGHTS AND COMPRESSION MEMBERS OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES

Item	Outsize Cargo Component			Weight (Kips)	Length Ft-In	Required Lift		LCM-8 Beam Load (Kips)	Counterweight		Remarks
						Morgan (Kips)	Alliance (Kips)		Morgan (Kips)	Alliance (Kips)	
1	3x15 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	137	92-0	235.0	267.9	204.0	67.0	99.9	Both cranes satisfactory
		b	4 Internal Spudwells	142	92-0	242.4	276.3	211.4	69.4	103.3	Both cranes satisfactory
		c	4 External Spudwells	142	92-0	242.4	276.3	211.4	69.4	103.3	Both cranes satisfactory
		d	6 Internal Spudwells	144	92-0	245.4	279.8	214.4	70.4	104.8	Both cranes satisfactory
2	4x15 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	183	92-0	303.5	346.0	272.5	89.5	132.0	Both cranes satisfactory
		b	4 Internal Spudwells	188	92-0	310.9	354.4	279.9	91.9	135.4	Both cranes satisfactory
		c	4 External Spudwells	188	92-0	310.9	354.4	279.9	91.9	135.4	Both cranes satisfactory
		d	6 Internal Spudwells	190	92-0	313.9	357.8	282.9	92.9	136.8	Both cranes satisfactory
		e	6 External Spudwells	190	92-0	313.9	357.8	282.9	92.9	136.8	Both cranes satisfactory
3	4x10 Pontoon Causeway Intermediate Section (P-Series)	a	Standard	122	61-1	147.9	168.6	116.9	5.1 Lift	15.5	2 Beam Lift Both cranes satisfactory. NOTE 1
		b	4 Internal Spudwells	137	61-1	162.3	185.0	131.3	5.7 Lift	16.9	2 Beam Lift Both cranes satisfactory. NOTE 1
		c	4 External Spudwells	127	61-1	152.7	174.0	121.7	5.3 Lift	16.0	2 Beam Lift Both cranes satisfactory
4	AMMI Pontoon Causeway			110	90-0	191.0	217.7	160.0	50.0	76.7	Both cranes satisfactory

TABLE 4.2 LCM-8 LIFTING BEAM WITH COUNTERWEIGHTS AND COMPRESSION MEMBERS
OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES (Continued)

Item	Outsize Cargo Component			Weight (Kips)	Length Ft-In	Required Lift		LCM-8 Beam Load (Kips)	Counterweight		Remarks
						Morgan (Kips)	Alliance (Kips)		Morgan (Kips)	Alliance (Kips)	
5	Piling	a	Single	6.2	60.0	37.2	42.4	6.2	NA	5.2	Athwartship Lift Both cranes satisfactory
		b	Bundle of 3	18.7	60.0	49.7	56.7	18.7	NA	7.0	Athwartship Lift Both cranes satisfactory
6	Water-Jet Propelled Causeway			169	90-0	230.43	262.69	199.43	30.43	62.69	Both cranes satisfactory.
7	3 x 14 Pontoon Warping Tug			194	90-0	273.2	311.45	242.2	48.2	86.5	Both cranes satisfactory.
8	Side Loadable Warping Tug	a	w/Outboard Propulsion	227	91-0	314.4	358.4	283.5	56.5	100.5	Both cranes satisfactory.
		b	w/Water-Jet Propulsion	230	91-8	315.52	359.7	284.52	54.5	98.7	Both cranes satisfactory.
9	LCM-6			56	56-2	87.0	99.2	56.0	0	12.2	Both cranes satisfactory. NOTES 2, 3
10	LCM-8	a	Aluminum	115	74-3	146.0	166.4	115.0	0	20.4	Both cranes are satisfactory. NOTES 3, 4
		b	Steel	134	73-8	165.0	188.1	134.0	0	23.1	

TABLE 4.2 LCM-8 LIFTING BEAM WITH COUNTERWEIGHTS AND COMPRESSION MEMBERS OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES (Continued)

Item	Outsize Cargo Component			Weight (Kips)	Length Ft-In	Required Lift		LCM-8 Beam Load (Kips)	Counterweight		Remarks
						Morgan (Kips)	Alliance (Kips)		Morgan (Kips)	Alliance (Kips)	
11	Bucyrus-Erie MK-100 Marine Crane w/60' Boom	a	Bare Crane	111	92-0	142.0	161.9	111.0	0	19.9	Both cranes satisfactory
		b	On 3x15 Causeway w/6 Ext. Spudwells	255	92-0	287.3	327.5	256.3	1.3	41.5	Both cranes satisfactory.
		c	On 4x15 Causeway w/6 Ext. Spudwells	301	92-0	355.7	405.5	324.7	23.7	73.5	Considers different centers of gravity for crane and causeway. Both cranes are satisfactory.
		d	On 4x10 Causeway w/4 Ext. Spudwells	238	92-0	262.0	298.7	231.0	7.0	43.7	Considers shifting position of center of gravity. Both cranes are satisfactory
		e	On AMMI Causeway	221	92-0	236.7	269.8	205.7	15.3	48.4	Both cranes satisfactory

TABLE 4.2 LCM-8 LIFTING BEAM WITH COUNTERWEIGHTS AND COMPRESSION MEMBERS OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES (Continued)

Item	Outsize Cargo Component			Weight (Kips)	Length Ft-In	Required Lift		LCM-8 Beam Load (Kips)	Counterweight		Remarks
						Morgan (Kips)	Alliance (Kips)		Morgan (Kips)	Alliance (Kips)	
12	P & H 9125 Truck Crane w/60' Boom	a	Bare Crane	190	94-0	221.0	251.9	190.0	0	30.9	Both cranes satisfactory
		b	On 3x15 Standard Causeway	327	94-0	332.7	379.3	301.7	25.3	71.9	Both cranes are satisfactory
		c	On 4x15 Causeway w/6 Ext. Spudwells	380	94-0	411.7	469.3	380.7	0.7	58.3	Both cranes are satisfactory
		d	On AMMI Causeway	300	94-0	288.8	329.2	257.8	42.2	82.6	Both cranes satisfactory
13	P & H 6250 Truck Crane	a	Bare Crane w/o Boom or Counter-weights	236	46-7	267.0	304.4	236.0	0	37.4	Both cranes are satisfactory
		b	Bare Crane w/70 Ft. Boom and Counter-weights	353	113-5	384.0	437.8	353.0	0	53.8	Both cranes are satisfactory

TABLE 4.2 LCM-8 LIFTING BEAM WITH COUNTERWEIGHTS AND COMPRESSION MEMBERS OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES (Continued)

Item	Outsize Cargo Component		Weight (Kips)	Length Ft-In	Required Lift		LCM-8 Beam Load (Kips)	Counterweight		Remarks
					Morgan (Kips)	Alliance (Kips)		Morgan (Kips)	Alliance (Kips)	
13	P & H 6250 Truck Crane (Continued)	c Bare Crane w/o Boom or Counter-weights on 4x15 Std. Causeway	419	92-0	441.1	502.9	410.1	8.9 Lift	52.9	Both cranes satisfactory. Slight overlift for Alliance.
		d Bare Crane w/o Boom or Counter-weights on 4x15 Cause-way with 6 External Spudwells	426	92-0	451.3	514.5	420.3	40.3	103.5	The LCM-8 Beam is rated at 448 Kips for the Morgan Crane. The Alliance Crane is not satisfactory See Note 5.
		e Bare Crane w/o Boom or Counter-weights on AMMI Cause-way	346	90-0	332.4	378.9	301.4	44.6 Lift	1.9	Both cranes are satisfactory
14	Mono-Mooring Pol Buoy (10 meter)		300		331.0	377.3	300.0	0	46.3	Both cranes sat-isfactory

TABLE 4.2 LCM-8 LIFTING BEAM WITH COUNTERWEIGHTS AND COMPRESSION MEMBERS
OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES (Continued)

Item	Outsize Cargo Component	Weight (Kips)	Length Ft-In	Required Lift		LCM-8 Beam Load (Kips)	Counterweight		Remarks
				Morgan (Kips)	Alliance (Kips)		Morgan (Kips)	Alliance (Kips)	
15	LACV 30	57	75-8	96.7	110.2	65.7	8.7	22.2	Both cranes satisfactory
16	LARC XV	45	45-0	76.0	86.6	45.0	0	10.6	Both cranes satisfactory
17	LARC LX	197	62-7	228.0	259.9	197.0	0	31.9	Both cranes satisfactory

NOTE 1. A beam is required on the forward lighter lifting sockets to provide a lift at the forward end of component (relative to ship). The C. G. of the component lies within the lighter frame and, if desired, can be shifted aft.

NOTE 2. Component calculations for centerline of component parallel to centerline of ship. Component could alternately be lifted with centerline athwartship directly under LCM-8 lifting beam.

NOTE 3. Counterweight not required. Load is balanced under slings.

NOTE 4. For Alliance Crane the load imparts a couple about the lower aft lighter frame sheaves. This is counteracted by the weight of the lighter frame itself.

NOTE 5. The LCM-8 beam will be certified at 448 Kips for Morgan Cranes.

The Alliance counterweight requirements are always greater due to the weight necessary to keep the lifting frame from rotating. The tendency of the lifting frame to rotate is due to the fact that the centerlines of the lifting sockets and the lifting pulleys do not coincide. The additional counterweight increases the required lift for the Alliance Crane by that amount, although the LCM-8 beam load is the same for both configurations. The highest counterweight required for the Alliance Crane is 136.8 Kips of which 72 Kips can be contributed by the lifting frame.

4.4 Use of Lifting Beams with Moveable Lift Points

When using the Morgan and Alliance Cranes converted to a 2-point lift employing the LCM-8 lifting beam between the after lifting sockets, it is necessary to use counterweights in most cases because the center of gravity for most outsize components falls outside the load frame. In some cases the necessary counterweight may be as much as 70% of the particular lift. The counterweight requirement for the Alliance Crane is somewhat more than that required for the Morgan Crane because the load frames are of different configuration. Refer to Figures 4.2 and 4.3.

Components tabulated in Table 3.1 that are compatible with existing load frames and handleable with the 4-point lift could perhaps more easily be handled with a 2-point lift permitting fore and aft orientation of the component. Even though the center of gravity of some components might fall on the LCM-8 lifting beam or within the load frame, a small counterweight may be desirable for stability.

In order to be effective, the counterweight should be great enough to satisfy the highest magnitude for any component and should be transmitted

directly to the forward extremity of the component by means of direct loading or through a compression member. In the latter case, the counterweight would be fastened to the forward two lifting sockets of the lifting frame, by means of a beam similar to the LCM-8 lifting beam. The counterweight load would be transmitted to the cargo component through an adjustable compression member.

The counterweight proper may be composed of a fixed weight or weights attached to a strongback or the counterweight may be fluid consisting of salt water in which case the counterweight could be adjustable, by controlling the amount of ballast counterweight.

Applying a fixed counterweight to the component itself or applying ballast to facilitate the lift would impose a trim problem on the component once it is detached from the hoist and it becomes buoyant.

To provide flexibility for lateral movement while the counterweight is attached, a mechanical device should be provided to permit lateral movement of the compression member while it is under counterweight load. The same provision should be made for the lifting padeyes, in order to provide the freedom of movement necessary for proper positioning of cargo during loading and off-loading modes. Lateral movement of the load would permit loading and off-loading operations in the center of the stern well, which is a more practical location for controlling pendulation under sea state 3 conditions.

4.4.1 <u>LCM-8 Lifting Beam with Lateral Winch</u>

In order to shift the load laterally to facilitate positioning of cargo components for stowing, and to permit off-loading on the centerline of the stern well, it is suggested that a powered system be provided to permit lateral

transitional movement of the load. Several mechanical means have been considered including a rack and pinion, a worm gear and a hydraulic mechanism to translate motion to a trolley carriage moving on two rails attached to the sides of the lifting beam. Refer to Figures 4.7 through 4.10.

Two rails have been provided on the sides of the beam supporting a transverse type carriage, rather than a single rail on the bottom of the beam in order to keep the vertical distance to a minimum.

A two directional constant tension winch is mounted on top of the beam[1]. Through a system of pulleys at either end of the beam, motion is imparted to the trolley carriage in either direction for approximately 90% of the beam length, permitting the positioning of cargo components from extreme port to extreme starboard within the limits of the LASH gantry frame.

Existing lifting beams can be modified in this manner and additional new ones fabricated accordingly. If later developments show that there is sufficient vertical clearance, the design can be simplified to provide a single rail on the bottom of the beam. With this design it will be feasible only to complete single component lifts.

An alternate method of providing lateral motion to the load is by using a gear motor driven pinion and a stationary rack as shown in Figure 4.8. The stationary rack extends the length of the lift beam. As the pinion meshes in the rack, it imposes lateral motion to the trolley which carries the padeye and load. Electrical current is supplied to the motor through an energized rail mounted parallel to the rack and extending the length of the beam.

Although more expensive, this is probably a more positive means

(1) The LCM-8 Lift Beam has a factor of safety of approximately 4.6 to 1.

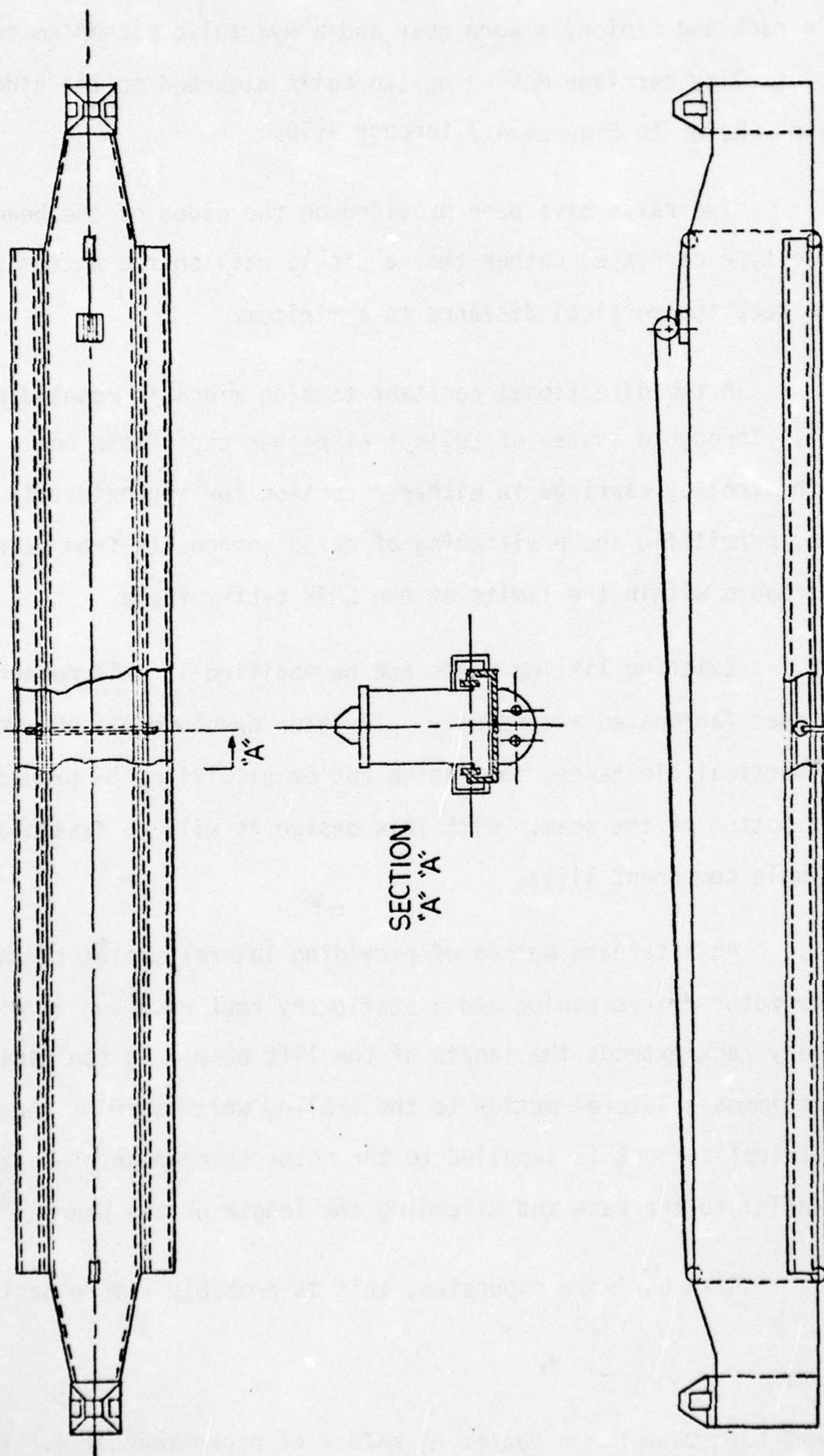


Figure 4.7 Lifting Beam With Lateral Winch

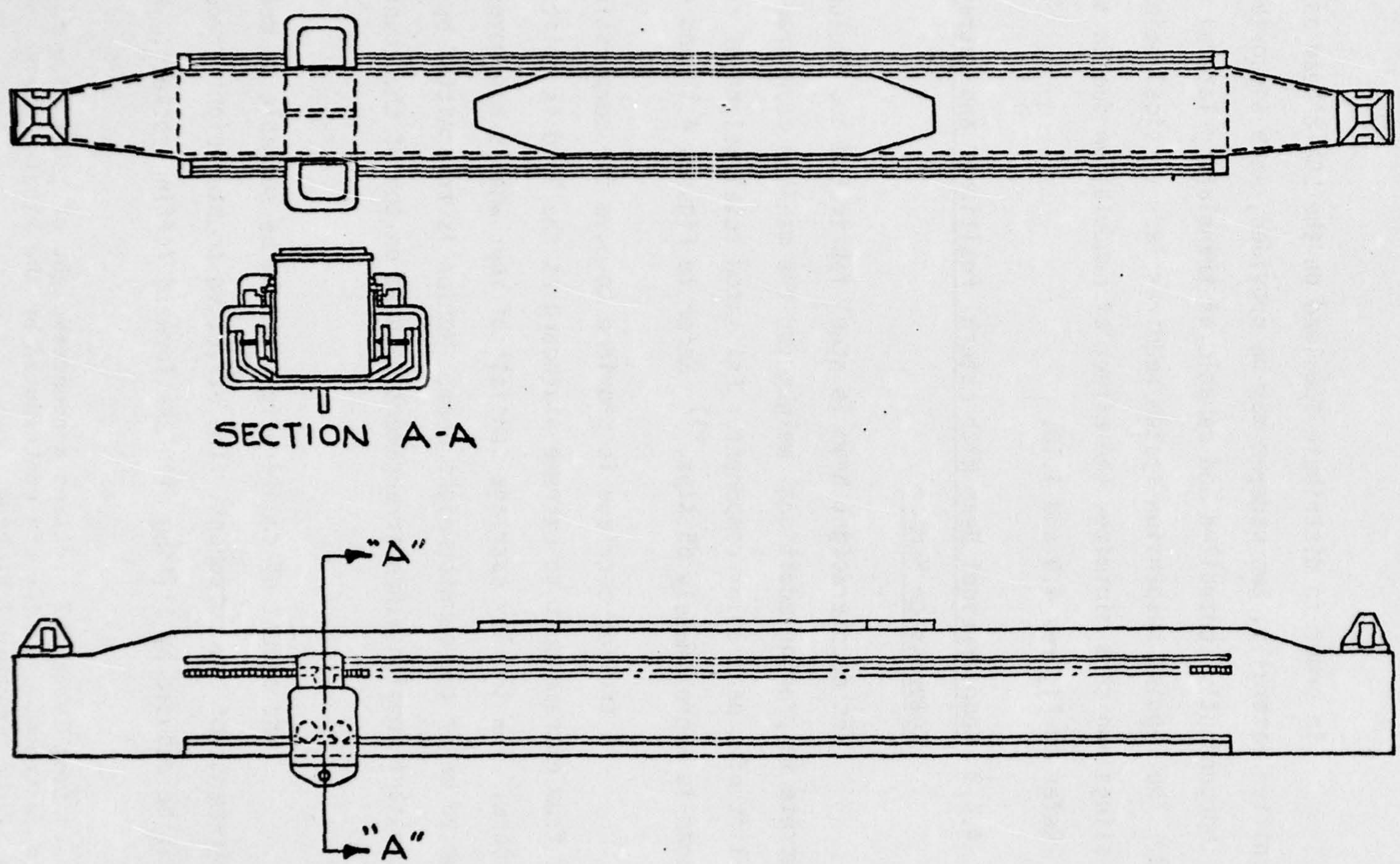


Figure 4.8 Lifting Beam With Rack and Pinion

of providing lateral motion to the load. To insure that there is no tendency of the load to move as the ship may roll, a magnetic brake is provided as a safety feature.

In order to distribute the load on the LCM-8 beam as the component is shifted laterally, two padeyes may be provided, each supported by a trolley independently controlled and capable of translating lateral motion to the load. The 2-point suspension system requires less vertical height to the lifting slings and thus minimizes the effect of pendulation due to the ship's motion. Refer to Figures 4.9 and 4.10.

4.4.2 Counterweight Beam With Lateral Positioner and Retractable Compression Member

The counterweight beam is steel fabricated and includes integral cast concrete to provide additional weight for the maximum counterweight required for any lift of a particular component. Estimated total weight of the counterweight beam is approximately 65 Kips.(1) Refer to Figures 4.11 and 4.12.

A trolley carriage is provided to move the compression component assembly from extreme port to extreme starboard as the load is shifted on the lifting beam. The trolley carriage consists of four wheels and moves on a single rail mounted under the counterweight beam. Motion is transmitted by a two dimensional constant tension winch arrangement mounted on top of the counterweight beam.

The amount of counterweight should be suitable to meet the maximum requirements of any component. The effective counterweight force on any component can be reduced by lifting with the forward lifting sockets. When lesser

(1) Item 2d from Table 4.2 requires a counterweight of 136.8 Kips for the Alliance Crane. 72 Kips are contributed by the lifting frame and 64.8 Kips by the counterweight beam.

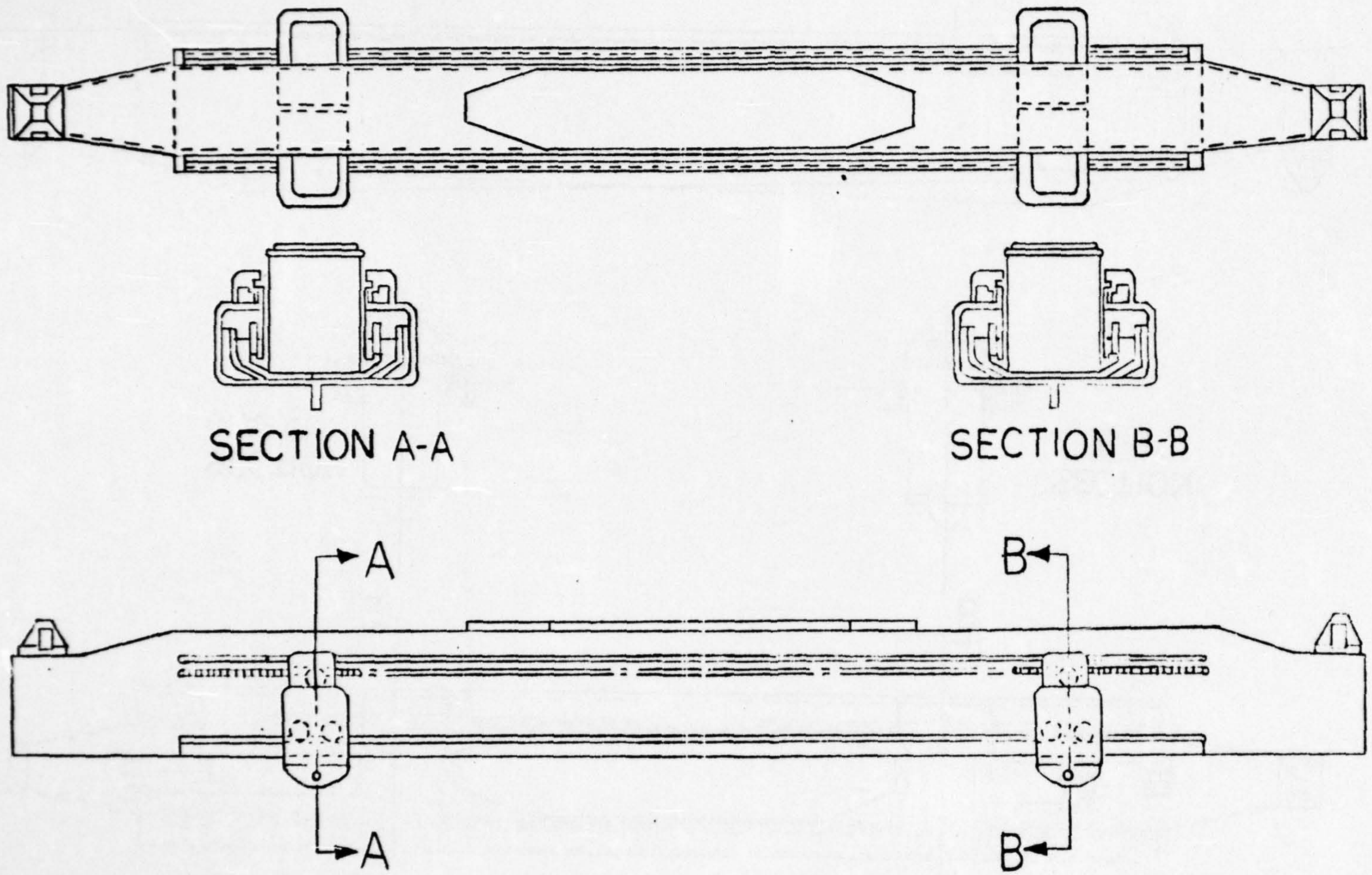


Figure 4.9 2-Point Suspension System - Rack and Pinion

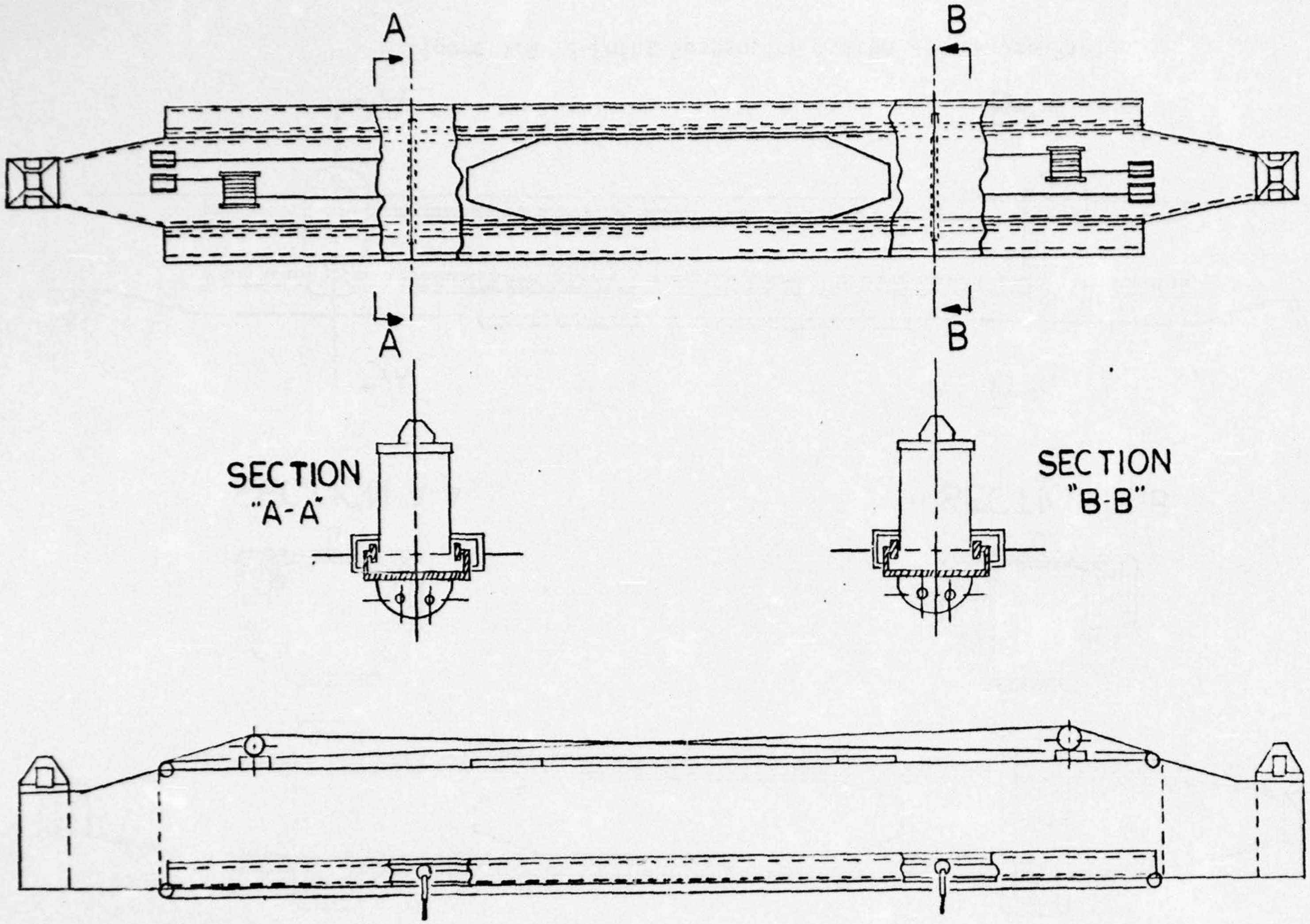


Figure 4.10 2-Point Suspension System - Lateral Winch

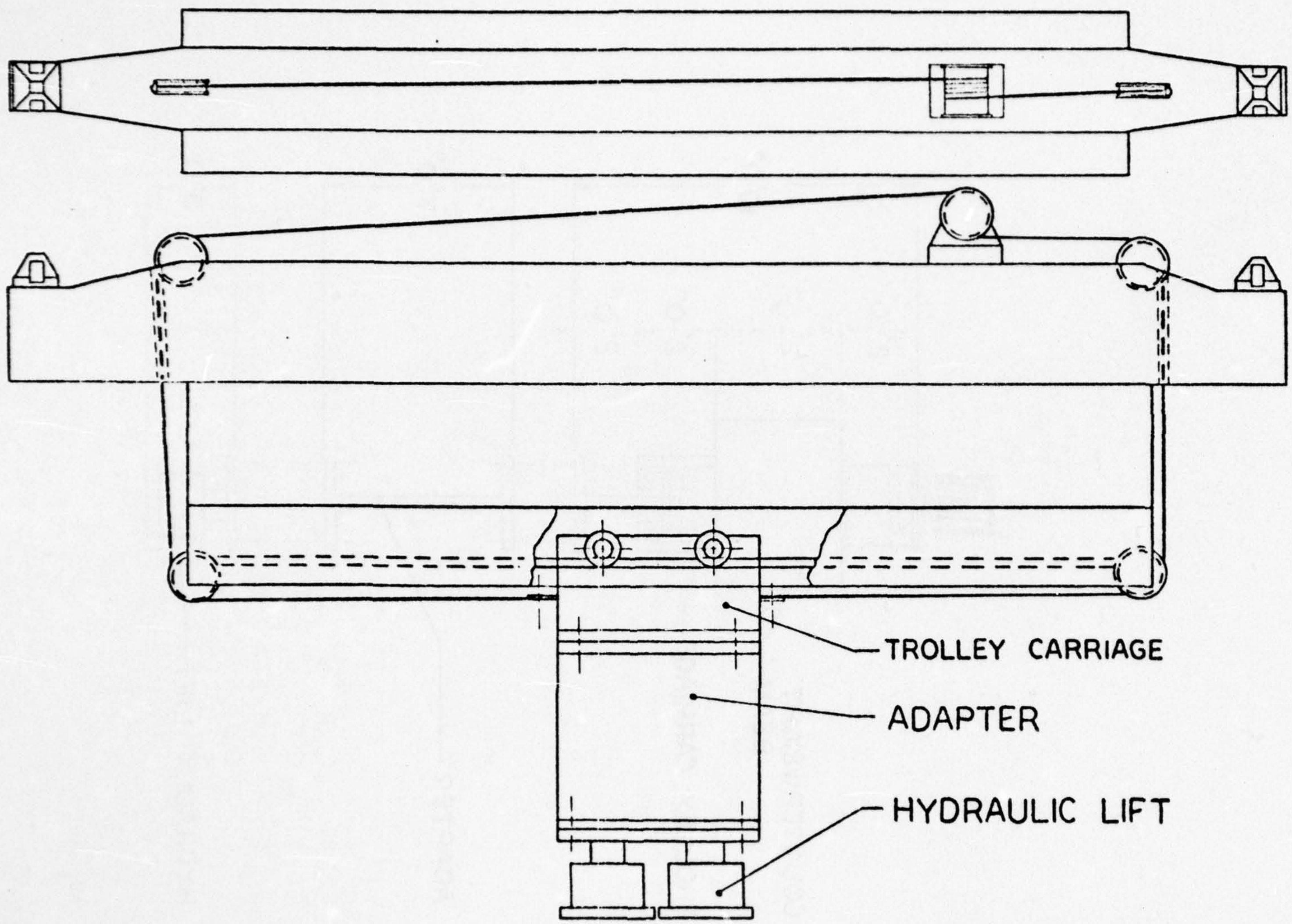


Figure 4.11 Counterweight Beam With Winch/ Trolley Carriage - Elevation & Plan

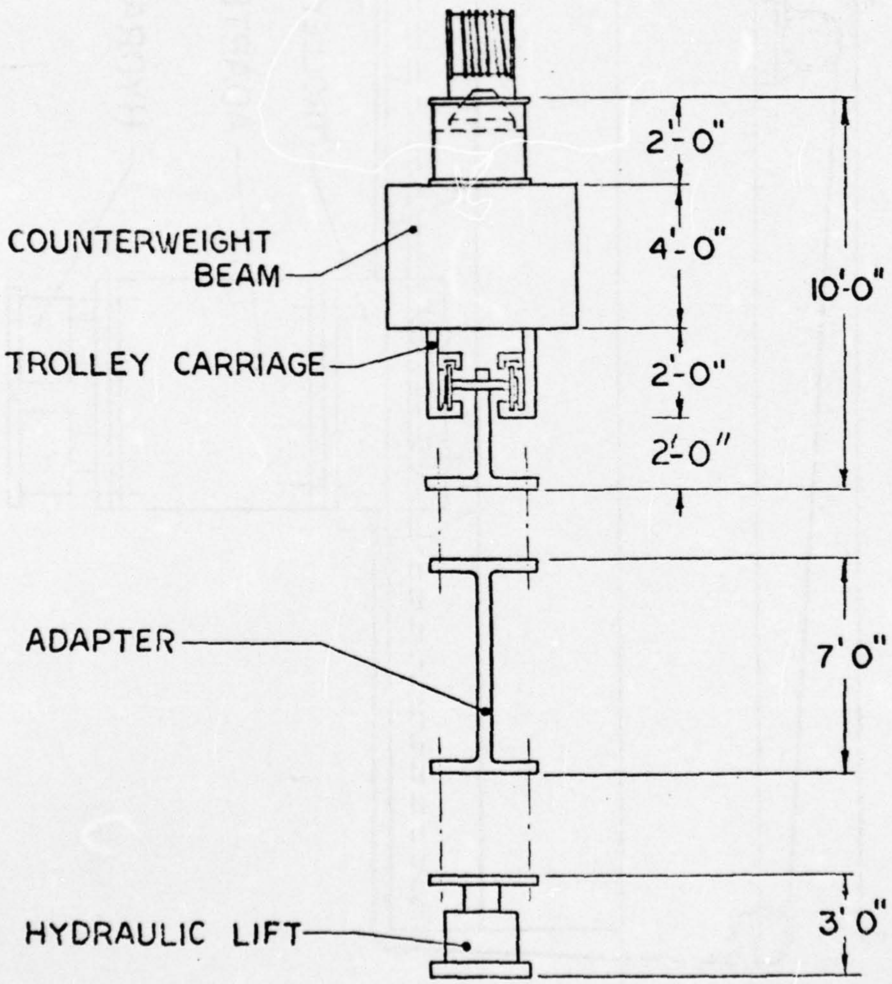


Figure 4.12 Counterweight Beam With Winch and Trolley - Section

counterweights are required, the excess counterweight is supported by the two forward lifting sockets.

The counterweight force is translated to the cargo component through a series of compression members as shown in Figure 4.12. The compression assembly consists of the trolley carriage, adapters and a hydraulic lift that can be adjusted. The vertical height of the compression assembly is equal to the sum of the lifting beam depth and the vertical height of the component lifting sling. In Figure 4.12 the combined length of the compression assembly is comparable to the 6'-0" depth of the lifting beam plus the vertical height of the LCM-8 lifting sling which is 13'-6". Inasmuch as the vertical heights for component slings may vary, additional adapters may be needed for other components where the 3'-0" stroke of the hydraulic lift is not adequate for vertical adjustment.

An alternate method of positioning the vertical counterweight member is by using a rack and pinion similar to the arrangement employed with the lifting beam. For details of this device refer to Figures 4.13 and 4.14.

4.5 Use of Cantilever Lift Frame With Moveable Lift Points

This particular concept envisions a lifting frame with a 17 foot cantilever extension as shown in Figures 4.15 and 4.16. Cross members are provided at the 17 foot cantilever position and at a forward position midway between the load frame lifting sockets. Bolted connections to the two longitudinal members are utilized to provide some degree of portability. If desired, several connections may be provided at several fore and aft positions to permit the cantilever lift frame to handle a greater variety of outsize cargo components.

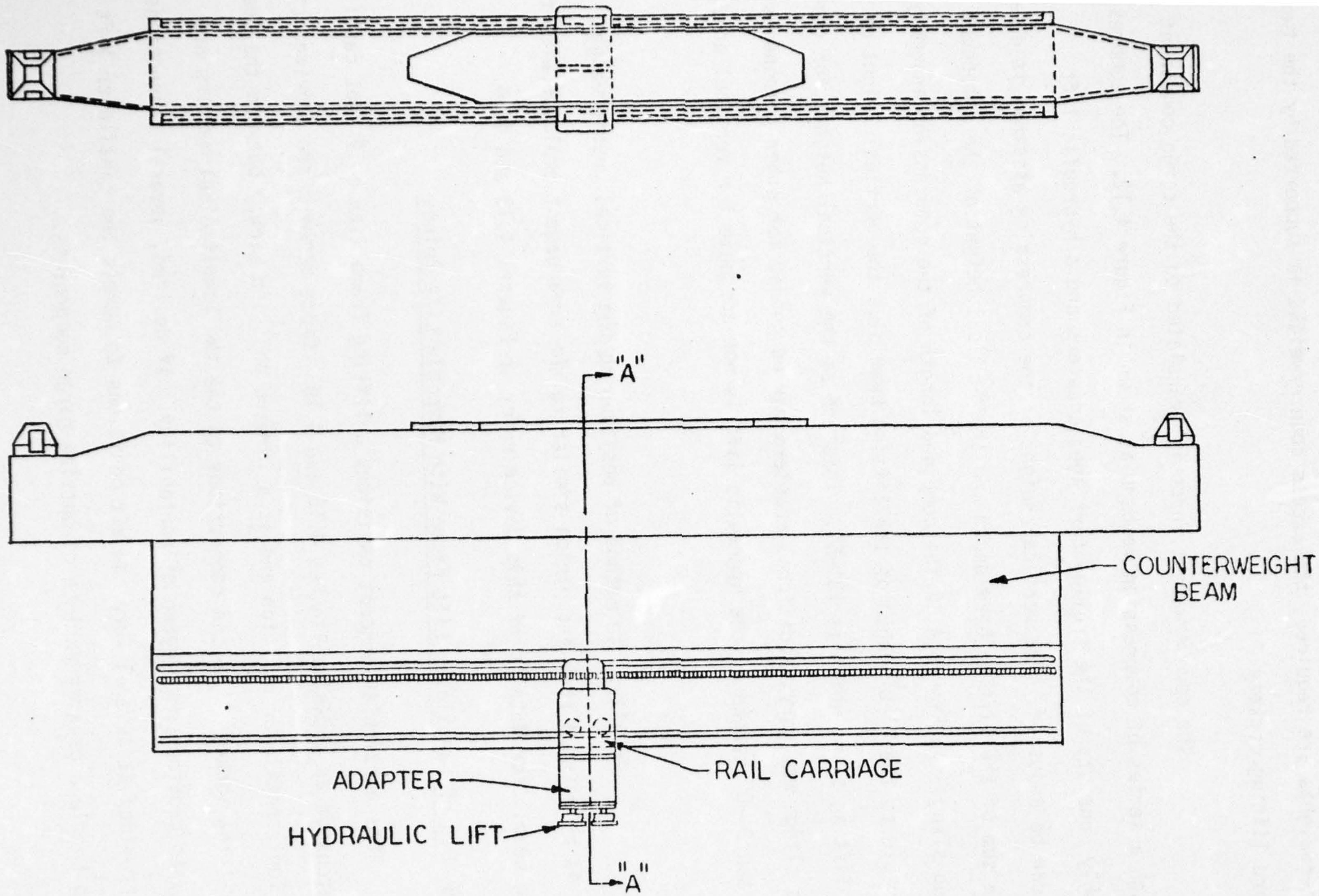


Figure 4.13 Counterweight Beam With Rail Carriage - Elevation and Plan

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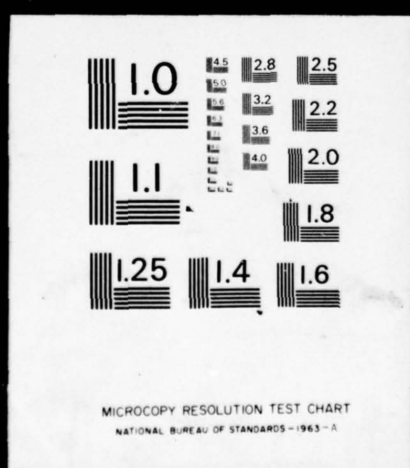


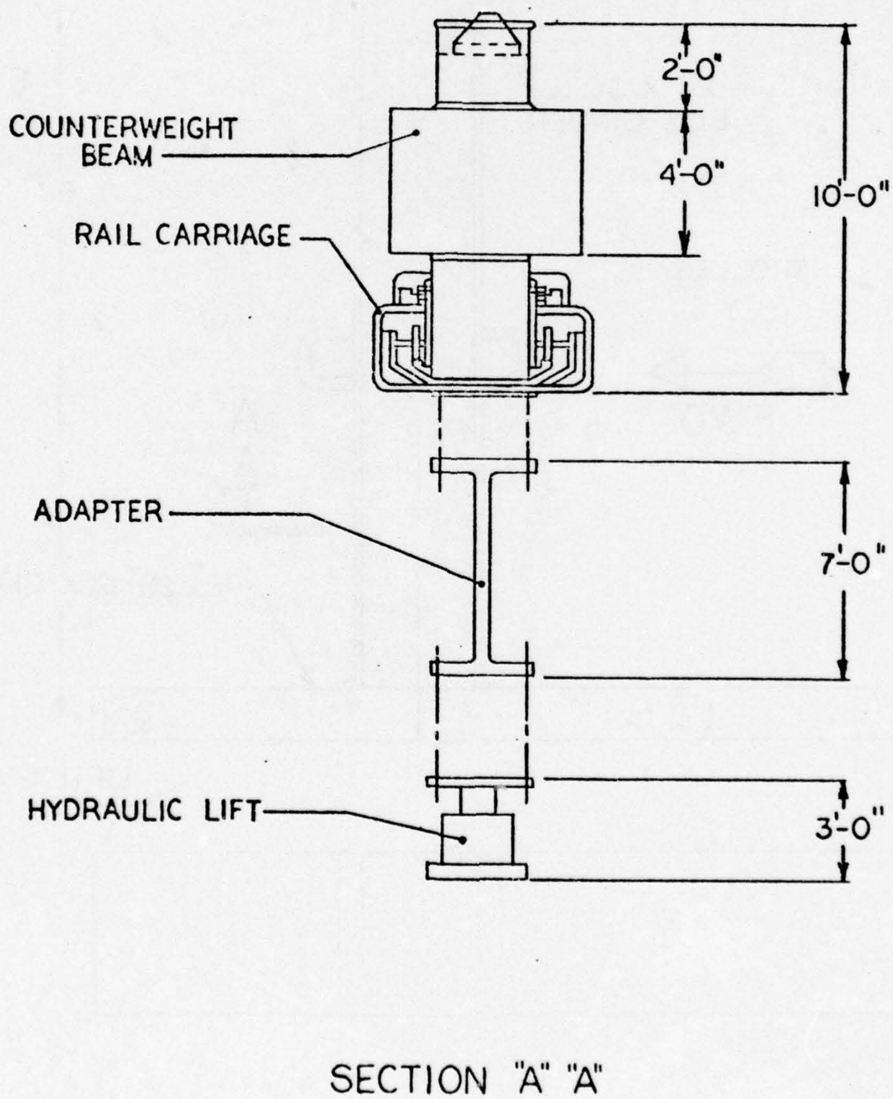


Figure 4.14 Counterweight Beam With Rail Carriage - Section

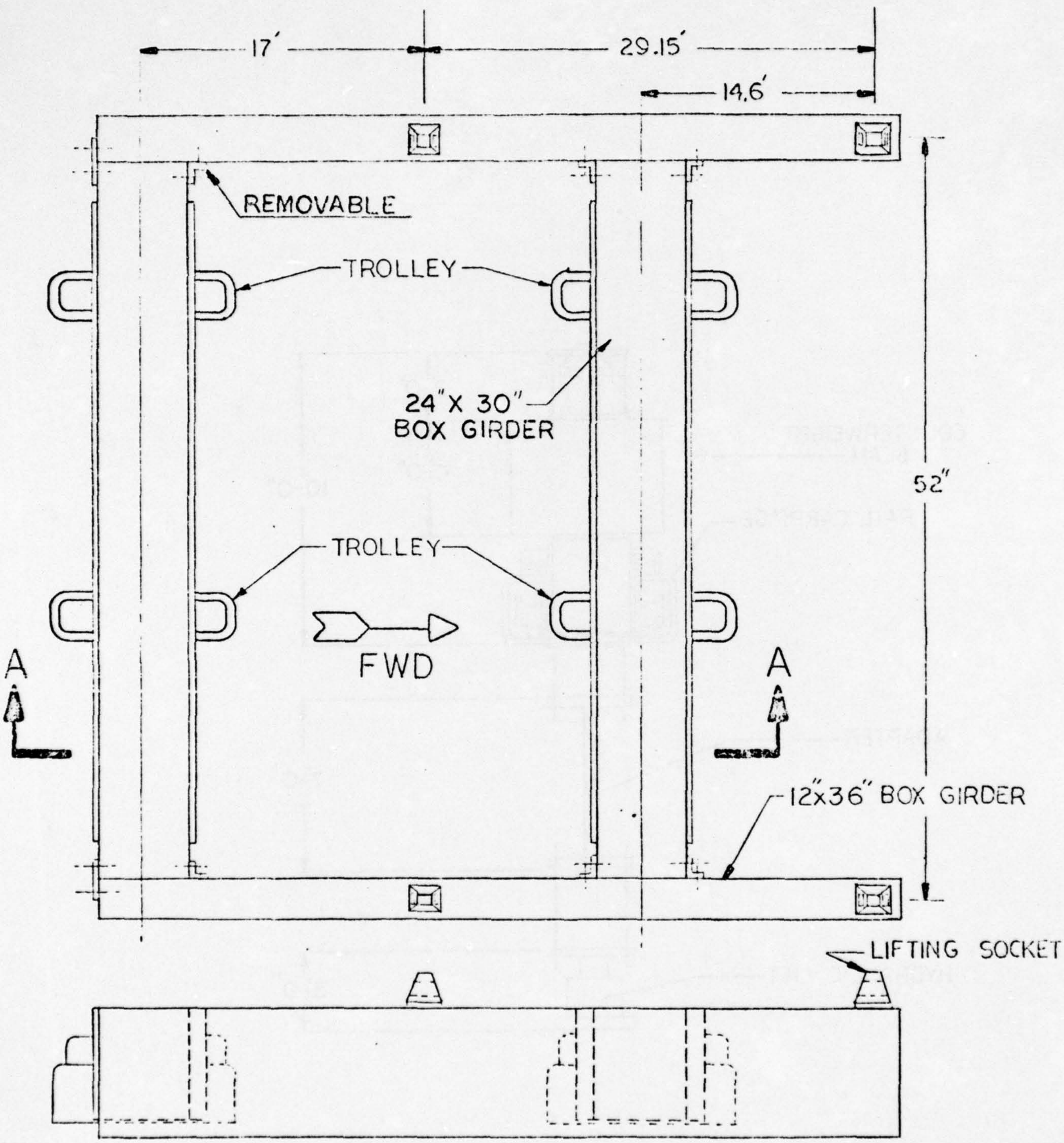
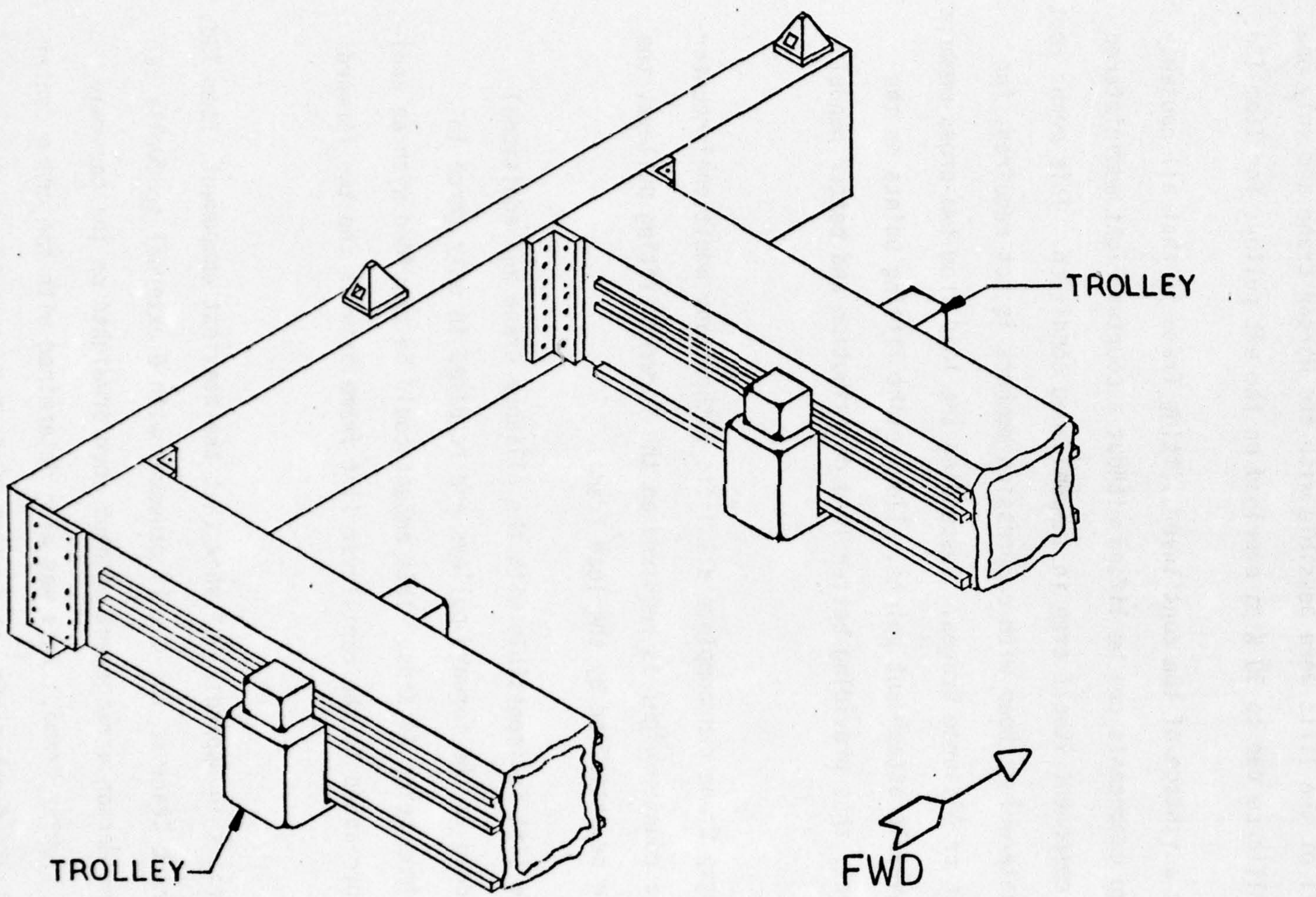


Figure 4.15 Cantilever Lift Frame With Moveable Lift Points



SECTION-A A

Figure 4.16 Cantilever Lift Frame With Moveable Lift Points (Isometric)

The calculations shown in Appendix "C" and summarized in Table 4.3, are based on having the cross members in the same fore and aft position as shown in Figure 4.15. All of the lifts were possible with the Morgan Crane and only one impossible for Alliance due to 30 Kips overload on the aft pulleys for Item 13d.

The big advantage of the cantilever lifting frame is that all causeway and outsize cargo components can be lifted without a counterweight administered to the causeway component itself even in the unloaded condition. This means that an elaborate counterweight beam with compression members is not required, for either the Morgan or Alliance Cranes. Suspending the load from two cross members, each with two moveable attachment points, allows eight lifting points on the causeway component, thus providing better load distribution and better pendulation control.

The Morgan Crane can complete all lifts without any additional counterweights. Where a counterweight is required on the forward lifting pulleys, the counterweight can be satisfied by the load frame.

Only one lift is impossible with the Alliance Crane and additional counterweights added to the forward pulleys are required in only three instances, the maximum being 44 Kips. This amount could be provided with an additional cross member added to the cantilever lift frame between the two forward lifting sockets.

Calculations in Appendix "C" show that the heaviest component, Item 13d, the P & H 6250 Truck Crane on the 4 x 15 causeway with 6 external spudwells can be lifted with the Morgan arrangement without counterweights on the causeway component or the lighter frame. This was also determined with the crane center of gravity relatively farther aft, at a point 20 feet from the forward end of the

TABLE 4.3 CANTILEVER LIFT FRAME
OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES

Item	Outsize Cargo Component	C. G.(2) From Fwd. End Causeway	Required Lifts (Kips) Morgan Aft Pulleys	Required Lifts (Kips) Morgan Fwd Pulleys	Required Lifts (Kips) Alliance Aft Pulleys	Required Lifts (Kips) Alliance Fwd Pulleys	Load Frame Forward Counterweights Morgan	Load Frame Forward Counterweights Alliance	Remarks
1e	3 x 15 Pontoon Causeway Intermediate Section (P-Series)	-	280.4	-38.7	332.2	-90.5	38.7	90.5	Both cranes are satisfactory. See Note 1. Requires additional 18.5 Kip counterweight on the Alliance load frame.
2e	4 x 15 Pontoon Causeway Intermediate Section (P-Series)	-	348.9	-61.2	415.5	-127.8	61.2	127.8	Both cranes are satisfactory. See Note 1. Requires additional 55.8 Kip counterweight on the Alliance load frame.
4	AMMI Pontoon Causeway	-	226.0	-18.3	265.7	-58.0	18.3	58.0	Both cranes are satisfactory. See Note 1.
6	Water-Jet Propelled Causeway	37.0	308.1	-5.1	358.9	-55.9	5.1	55.9	Both cranes are satisfactory. See Note 1.

TABLE 4.3 CANTILEVER LIFT FRAME
OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES (Continued)

Item	Outsize Cargo Component	C. G.(2) From Fwd. End Causeway	Required Lifts (Kips) Morgan Aft Pulleys	Required Lifts (Kips) Morgan Fwd Pulleys	Required Lifts (Kips) Alliance Aft Pulleys	Required Lifts (Kips) Alliance Fwd Pulleys	Load Frame Forward Counterweights Morgan	Load Frame Forward Counterweights Alliance	Remarks
7	3 x 14 Pontoon Warping Tug (P-Series)	39.0	308.2	-16.6	361.0	-69.3	16.6	69.3	Both cranes are satisfactory. See Note 1.
8b	Side Loadable Warping Tug With Water-Jet Propulsion	38.7	350.8	-23.1	411.5	-83.8	23.1	83.8	Both cranes are satisfactory. See Note 1. Requires additional 11.8 Kips counterweight on the Alliance load frame.
11b	Bucyrus Erie MK 100 Marine Crane With 60 Foot Boom on 3 x 15 Standard Causeway	17.2	335.9	16.8	387.7	-35.0	0	35.0	Actual center of gravity of truck crane is 11 feet from forward end. Both cranes are satisfactory. See Note 1.
12c	P & H 9125 Truck Crane With 60 Foot Boom on 4 x 15 Causeway With 6 External Spudwells	17.2	444.0	33.7	510.5	-32.8	0	32.8	At this position for the truck crane C. G. the Alliance crane is overloaded.

TABLE 4.3 CANTILEVER LIFT FRAME
OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITIES (Continued)

Item	Outsize Cargo Component	C. G.(2) From Fwd. End Causeway	Required Lifts (Kips)				Load Frame Forward Counterweights		Remarks
			Morgan		Alliance				
			Aft Pulleys	Fwd Pulleys	Aft Pulleys	Fwd Pulleys	Morgan	Alliance	
12c	(Continued)	15.0	429.7	48.0	491.6	-13.9	0	13.9	Both cranes are satisfactory when the C. G. of the truck is moved to 15 Ft. The counterweight on the forward pulleys is satisfied by the weight of the Alliance load frame.
13d	P & H 6250 Truck Crane on 4 x 15 Causeway With 6 External Spudwells	20.0	489.8	33.9	564.0	-40.3	0	40.3	The Alliance crane is not satisfactory because required lift exceeds maximum.
		17.0	465.5	58.2	532.0	-8.3	0	8.3	When moving the truck crane C. G. as far aft as possible to 17 Ft. the Alliance crane is still overloaded.

NOTE 1. The load frames for both Morgan and Alliance Cranes are assumed to contribute approximately 72 Kips to the forward pulleys.

NOTE 2. Position of center of gravity is measured from the forward end of causeway relative to its position in the LASH stern well. The cantilever lift frame weighs 97.7 Kips and has a C. G. of 19.7 feet.

causeway component than assumed in previous calculations. With the Alliance arrangement, the lift on the aft pulleys exceeded the crane rating.

The lift was recalculated for the Alliance arrangement with crane center of gravity at 17 feet from the forward end of the causeway. In this case there was a small overload on the after pulleys with a counterweight of 8 Kips required on the forward pulleys which is easily compensated for by the load frame.

Considering the heaviest of the unloaded causeway components, Items 2d and 2e at 190 Kips, these items can be lifted with the Morgan arrangement with the existing load frame contributing counterweight to the forward pulleys.

In the case of the Alliance arrangement additional counterweight(1) will have to be added to the forward end of the lighter frame in excess of the 72 Kips contributed by the load frame.

Calculations for the dimensions of the cantilever lift frame are included in Paragraph 10 of Appendix "C".

4.6 Use of Jib Boom on Lighter Crane

This arrangement for lifting causeway components consists of a simple jib boom and winch mounted on the after end of the LASH lighter crane, directly above the LCM-8 lifting beam. No counterweight beam is required with this arrangement when operating with a 2-point crane lift because the external lift is applied a convenient distance outside of the lighter lifting frame, sufficient to equalize the cantilever load.

(1) LCM-8 beam can be used as counterweight.

Indications are that a 50 foot jib would be satisfactory, mounted at a fixed 45 degree angle, providing an external lifting point 35.3 feet aft of the lifting beam. Hydraulic positioners are provided to support the boom and impart rotation sufficient to move the load from extreme port to extreme starboard. Refer to Figure 4.17 showing the jib and winch on the lighter gantry.

Capacity of the crane can be determined based on the following calculations, shown in Appendix "D" - Calculations For Use of Jib Boom on Lighter Crane. A summary of the required external and lighter crane lifts is included in Table 4.4.

Obvious advantages of the external lift method are that the component load can be placed farther aft than with other methods providing better flotation stability, and that no counterweight is required on the causeway component. The Morgan Crane configuration requires no counterweight on the load frame, whereas, the Alliance Crane requires a maximum of 53.2 Kips on the forward end of the load frame which can be compensated for by the weight of the load frame itself.

Calculations have been limited to Items 11c, 12c and 13d, which are the most difficult lifts.

4.7 Use of Pedestal Crane on Lighter Crane

With this particular arrangement it is envisioned to utilize the Alliance and Morgan Cranes without modification employing a 4-point lift. The lift at the center of the lighter crane frame configuration is far below the maximum capability of the crane, and the circuitry would not have to be changed in either case.

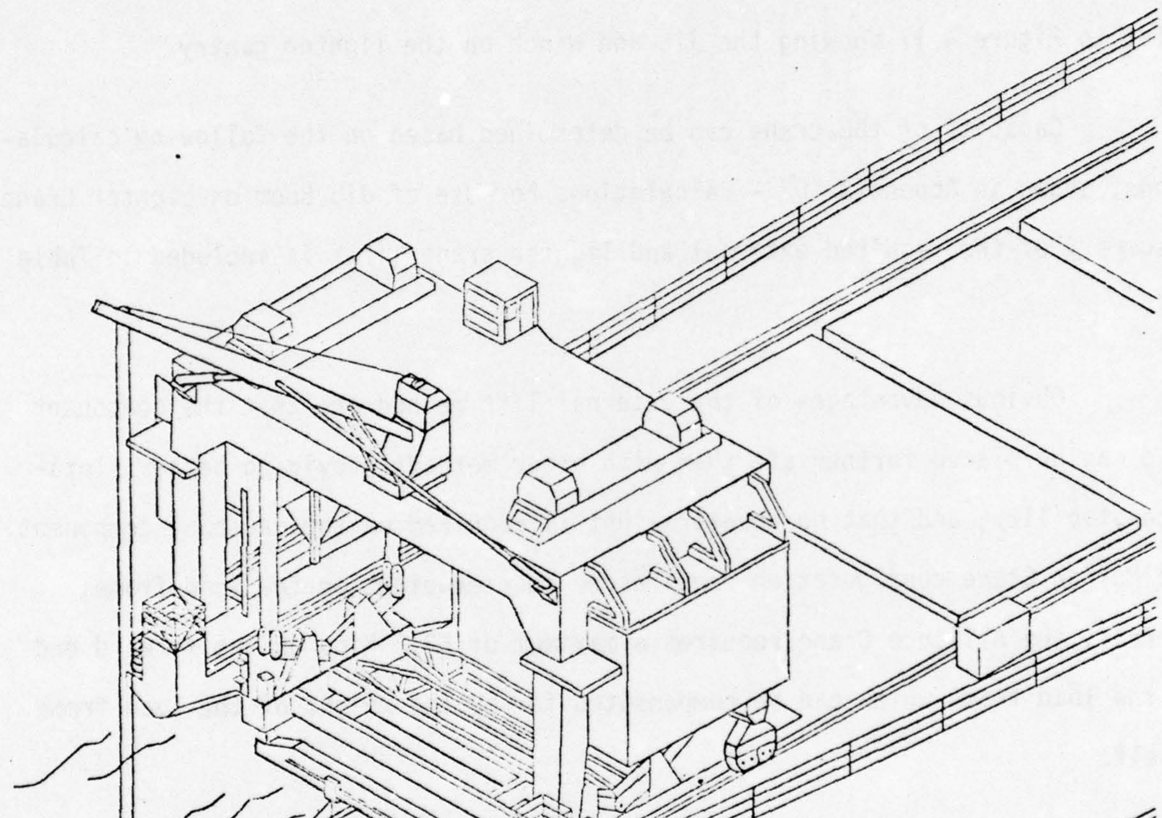


Figure 4.17 Jib Boom on LASH Lighter Crane

TABLE 4.4 JIB BOOM ON LIGHTER CRANE
(Outsize Cargo Component Discharge Capabilities)

Item	Outsize Cargo Component	(Feet) C.G. Position From Fwd. End of Causeway	Required Lifts			LCM-8 Beam Load (Kips)	Lifting Frame Counterweights		Remarks
			External (Kips)	Morgan (Kips)	Alliance (Kips)		Morgan (Kips)	Alliance (Kips)	
11c	Bucyrus Erie MK-100 Marine Crane w/60 ft. on 4 x 15 Causeway with 6 External Spudwells	11.	11.5	320.5	365.4	289.5	0	44.9	Both cranes satisfactory.
		31.75	76.7	255.3	291.0	224.3	0	35.7	Both cranes satisfactory.
12c	P & H 9125 Truck Crane on 4 x 15 Causeway with 6 External Spudwells	15.	-13.5	424.5	483.9	393.5	0	59.4	External lift not practical in this crane position. See next line.
		31.75	76.7	334.3	381.1	303.3	0	46.8	Both cranes satisfactory
13d	P & H 6250 Truck Crane on 4 x 15 Causeway with 6 External Spudwells	17.	-21.9	478.9	545.7	447.9	0	66.8	External lift not practical in this crane position. See next line.
		31.75	76.7	380.3	433.5	349.3	0	53.2	Both cranes satisfactory.

The external lift will be somewhat greater than that used with the jib boom, consequently a small revolving pedestal crane is considered for the external lifting element. For those ships that are not fitted with a container gantry, the pedestal crane could also be used to off-load containers in addition to handling causeway components. Length of the boom is approximately 70 feet with a horizontal reach aft of the lighter gantry load frame of about 35 feet. Refer to Figure 4.18.

Capacity of the crane will be determined by the following calculations using the most difficult items as examples, as shown in Appendix "E" - Calculations For Use of Pedestal Crane on Lighter Crane".

For a comparison of the external lifts required when using an external 4-point lift, refer to Table 4.5.

4.7.1 Adapter for 4-Point Lifts

The 2-point lift used with the jib and winch taxes the LCM-8 Lifting Beam almost to capacity although the required external lift is somewhat less, requiring less expensive equipment on top of the gantry.

The 4-point lift employing the pedestal crane on top of the gantry requires a somewhat greater external lift but less load on the gantry, thus simplifying the lifting frame.

Reference is made to Tables 4.4 and 4.5 which show the differences between the two and four point lifting methods.

Because the loads using the 4-point lift with the lighter gantry are considerably less than with the 2-point lifting arrangement, the adapter

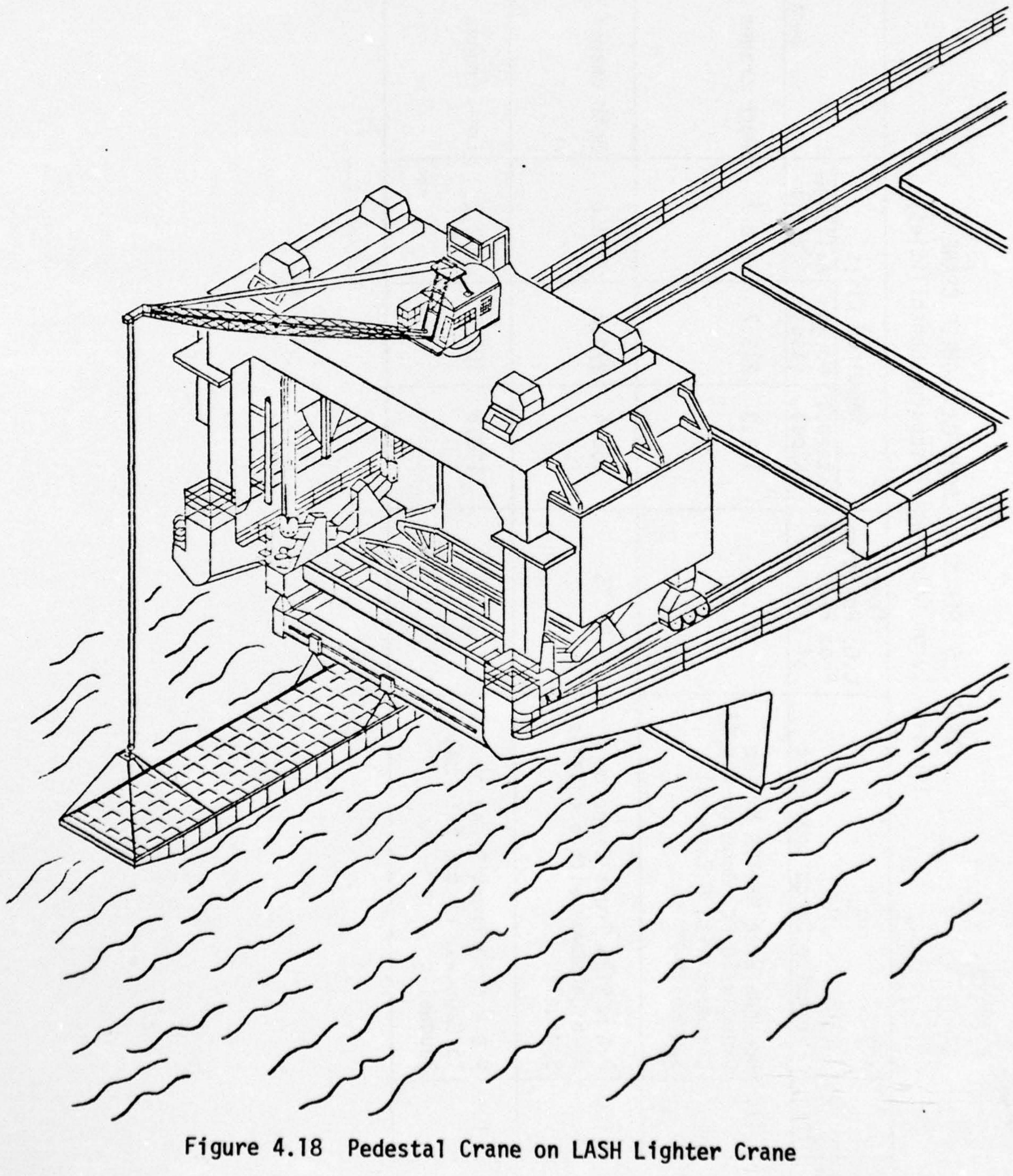


Figure 4.18 Pedestal Crane on LASH Lighter Crane

TABLE 4.5 PEDESTAL CRANE ON LIGHTER CRANE
(Outsize Cargo Component Discharge Capabilities)

Item	Outsize Cargo Component	(Feet) C.G. Position From Fwd. End of Causeway	Required Lifts External (Kips)	Required Lifts Morgan (Kips)	Required Lifts Alliance (Kips)	Remarks
11c	Bucyrus Erie MK-100 Marine Crane w/60 Ft. Boom on 4 x 15 Causeway with 6 External Spudwells	31.75	142.3	218.7	218.7	Both cranes satisfactory
12c	P & H 9125 Truck Crane on 4 x 15 Causeway with 6 External Spudwells	31.75	165.4	274.6	274.6	Both cranes satisfactory
13d	P & H 6250 Truck Crane on 4 x 15 Causeway with 6 External Spudwells	31.75	178.8	307.2	307.2	Both cranes satisfactory

structure can be somewhat simpler and lighter than the LCM-8 Lifting Beam. This should reduce the fabrication cost and improve the vertical clearance available.

An adapter using an athwartship cross member for center loading with the 4-point system can be considerably shallower than the LCM-8 Lifting Beam because the maximum load is only 300 Kips with the heaviest cargo component. Refer to Figure 4.19 showing an adapter designed to be used with the conventional 4-point lifting system where both cranes remain unmodified.

4.7.2 Load Calculations

Safe load calculations for the 4-point lifting adapter can be calculated from the following formula:

$$L = \frac{2\ S\ b\ h^2}{3\ \ell}$$

Where L = Load of 300 Kips

S = Stress of 18,000 psi

b = Width of beam in inches

h = Height of beam in inches

ℓ = Length of the beam in inches

Assuming a convenient flange width of 24 inches, the depth of the athwartship center cross member can be determined as follows:

$$h^2 = \frac{3\ (52)\ (300)\ (12)}{2\ (18{,}000)\ (24)}\ \frac{\text{in. Kips}}{\text{Lb./in.}}$$

$$h^2 = \frac{156{,}000}{240} = 650\ \text{in.}^2$$

$$h = \sqrt{650} = 25.5\ \text{inches}$$

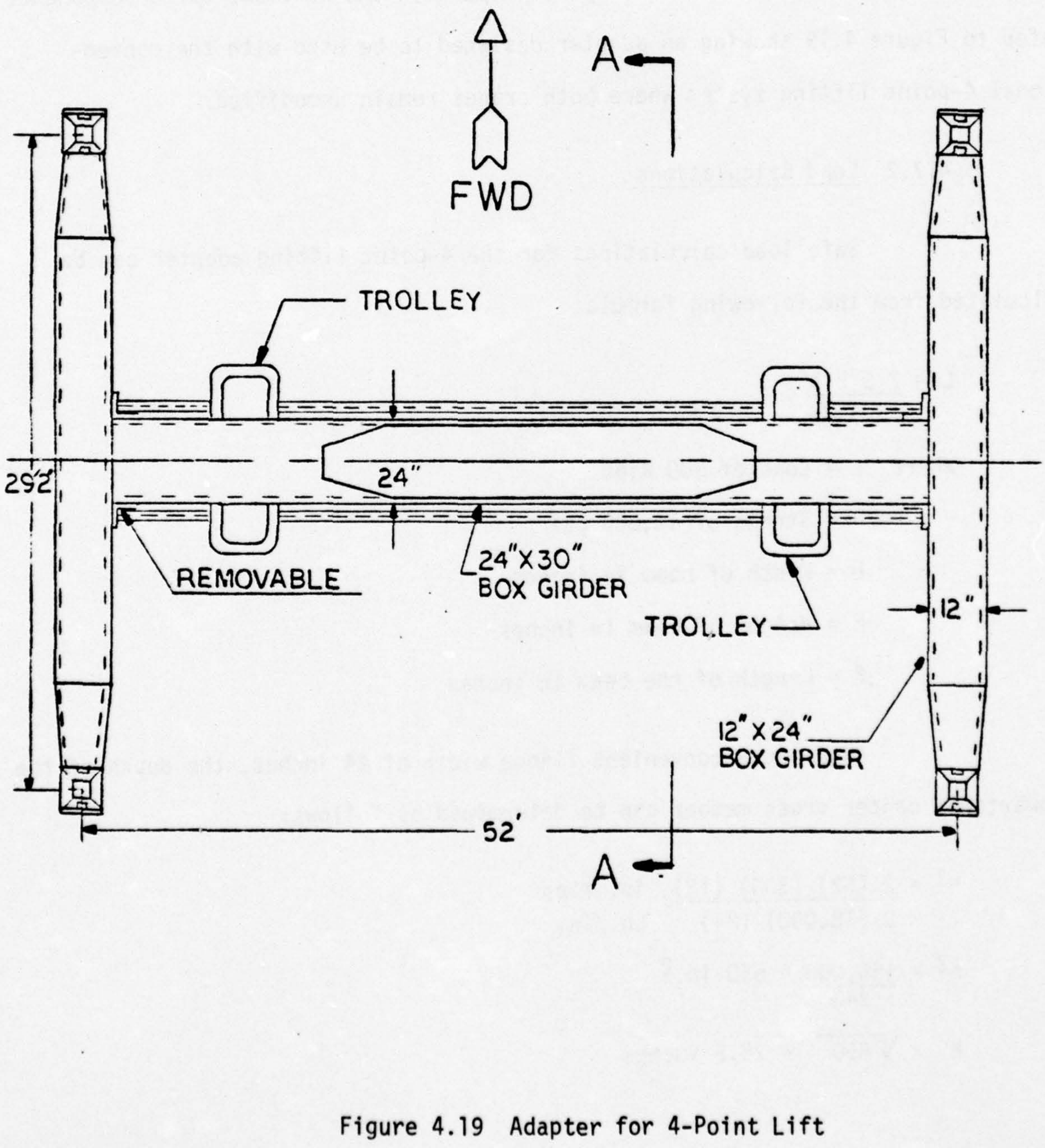


Figure 4.19 Adapter for 4-Point Lift

In a similar manner, the depth of the two fore and aft socket beams can be determined. Using a convenient beam width of 12 inches and a length of 29 feet, we have the following calculations:

$$h^2 = \frac{3\ (19)\ (300)\ (12)}{2\ (18{,}000)\ (12)} \quad \frac{\text{in. Kips}}{\text{Lb./in.}}$$

$$h^2 = 475 \text{ in.}^2$$

$$h = \sqrt{475} = 21.8 \text{ inches}$$

Based on the above calculations, the fore and aft beams can be 12" x 24" and the load cross member 24" x 30" box section beams. This should provide an additional 3.5 feet vertical clearance as compared to the LCM-8 beam. Refer to Figures 4.19 and 4.20 - Adapter for 4-point lift.

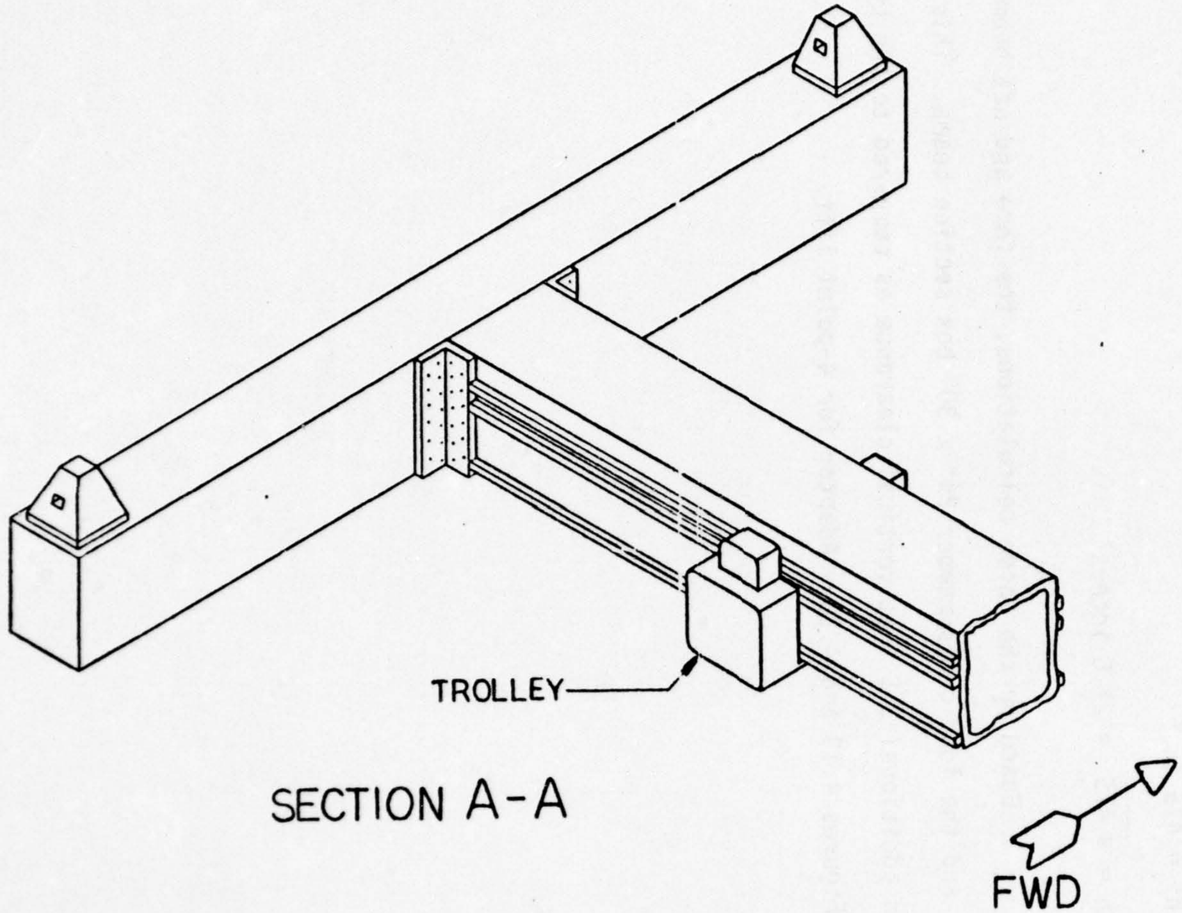


Figure 4.20 Adapter for 4-Point Lift (Isometric)

5. BUOYANCY AND STABILITY OF OUTSIZE CARGO COMPONENTS

In this section we will address those outsize cargo components that have been unsymmetrically loaded to facilitate lifting capabilities. The following buoyancy load calculations will determine the degree of stability and the amount of freeboard remaining after the cargo component has been discharged in the stern well. Refer to Appendix "F" - Calculations For Trim and Stability of Outsize Cargo Components.

Only the more difficult lifts such as loaded causeway components, Items 11b, 11d, 12b, 12c and 13c, are considered in this analysis. In calculating the buoyancy and the amount of trim forward and aft, the center of gravity for the crane loads was assumed to be in the same position as in lift calculations employing a 2-point lift and the LCM-8 lifting beam.

In most cases the crane weight was too far forward to provide suitable stability which was assumed to be a minimum freeboard of one foot either forward or aft. In those cases where the trim ended up with too little freeboard, the lift was recalculated with the crane weight in a position farther aft. The position of the crane and the distance that it was moved farther aft, were calculated on the the basis of the load limit of the LCM-8 lifting beam. In most cases, the cranes could be moved farther aft to improve trim and stability. Stability calculations were repeated with each change of crane position to determine resultant changes in freeboard.

Forces in buoyancy and displacement cubic were corrected for losses in buoyancy due to spaces between pontoons making up each causeway configuration. This is referred to in the calculations as a "correction factor".

For a summation of comparative trims for the several outsize cargo components, refer to Table 5.1 - Summary of Trim Calculations. Item 13c trim could not be improved by moving the center of gravity of the crane aft without exceeding the load limit of the lifting beam. It follows that this item may require another lifting technique.

When utilizing the LCM-8 lift beam with counterweights and compression members there is a limit to how far aft we can place the center of gravity of component loads such as the P & H 6250 Truck Crane without exceeding the capacity of the LCM-8 lift beam. For this reason, the 3 x 15 and 4 x 15 pontoon causeways have unsatisfactory trim fore and aft when loaded. The situation can be corrected in several ways; a lifting technique can be used such as the external lift or cantilever lift frame permitting the center of gravity to be placed farther aft; the load may be shifted farther aft when the lift is completed and the causeway is floating in the stern well; or a carrier component having greater load capacity, such as the AMMI pontoon causeway may be used.

The AMMI pontoon causeway has a normal depth of 5 feet. Calculations from Paragraph 6, Appendix F, indicate a final freeboard forward of 1.5 feet and 4.2 feet aft with the truck center of gravity 31.2 feet aft of the forward end of the AMMI causeway.

5.1 Transverse and Longitudinal Stability

To determine the transverse stability of the loaded outsize cargo component, we have based our calculations on one of the most difficult examples. Refer to Paragraph 7, Appendix F, Roll Stability Calculations For Item 13c - P & H 6250 Truck Crane on 4 x 15 Pontoon Causeway. In this particular example the trim was unsatisfactory with the forward end of the pontoon 0.85 feet under

TABLE 5.1 SUMMARY OF TRIM CALCULATIONS(1)

Item	Description	C.G. Dist. From Fwd. End of Causeway	Freeboard Fwd. Feet	Freeboard Aft Feet	Remarks
11b	Bucyrus Erie MK-100 Marine Crane on 3 x 15 Causeway with 6 External Spudwells	13.6	0.45	5.01	Unsatisfactory. See next line.
		46.0	2.66	2.66	Moved crane to center of causeway component. Satisfactory.
11d	Bucyrus Erie MK-100 Marine Crane on 4 x 10 Causeway	13.6	1.33	4.75	Satisfactory.
12b	P & H 9125 Truck Crane on 3 x 15 Standard Causeway	17.6	-1.46	5.50	Unsatisfactory. Bow is 1.46 feet under water and the stern is out of the water 0.25 feet.
		35.2	0.69	3.35	17' is the maximum distance that truck crane can be moved aft without exceeding LCM-8 beam load rating. Trim is not satisfactory.
12c	P & H 9125 Truck Crane on 4 x 15 Causeway	17.6	-0.17	5.05	Unsatisfactory. Bow is awash 0.17 feet.
		23.1	0.34	4.54	Crane is maximum distance aft. Unsatisfactory.
13c	P & H 6250 Truck Crane on 4 x 15 Causeway with 6 External Spudwells	19.6	-0.85	5.15	Unsatisfactory because bow is 0.85 feet under water. Crane can only be moved 0.8 feet farther aft which is insignificant in changing trim.

NOTE 1: Trim calculations based on LCM-8 Lifting Beam Technique with counterweight and compression members.

TABLE 5.1 SUMMARY OF TRIM CALCULATIONS(1)

Item	Description	C.G. Dist. From Fwd. End of Causeway	Freeboard Fwd. Feet	Freeboard Aft Feet	Remarks
13e	P & H 6250 Truck Crane on AMMI Causeway	17.0	0.1	5.6	Unsatisfactory
		31.2	1.5	4.2	Satisfactory after the crane is moved aft.

the water and a draft aft of 0.10 feet.

In spite of the adverse trim condition, the loaded pontoon has positive stability with a GM equal to + 17.94 feet. On this basis, it can be presumed that the loaded outsize cargo components have positive transverse stability.

Longitudinal stability of Item 13c is calculated in Paragraph 8 of Appendix "F". Because the longitudinal GM is over two and one half times the length of the loaded causeway component, the causeway section is considered longitudinally stable.

6. COMPARISON OF LIFTING TECHNIQUES

From an analysis of the discussions and calculations in previous paragraphs, it can be determined that there are four viable total lifting systems for handling outsize cargo components. These are as follows:

1. LCM-8 lifting beam, with counterweight and compression members and lateral transition devices.
2. Cantilever lift frame with moveable lift points.
3. Jib boom on lighter crane.
4. Pedestal crane on lighter crane.

In the following paragraphs, it is the intent to tabulate the advantages, disadvantages and the relative cost of each system. Refer to Table 6.1.

6.1 LCM-8 Lifting Beam, Counterweight Compression Members and Moveable Lift Points

Advantages

This method is perhaps the simplest in scope considering that three LCM-8 lifting beams are in existence. Additional requirements would include a counterweight beam and compression members.

The lifting beam and counterweight would be relatively portable and could be applicable to all C-8 and C-9 ships including Morgan and Alliance Crane configurations, depending on availability. However, C-8 ships would require modifications to lighter crane circuitry.

Ship down time would be a minimum requiring no ship erection time, i.e., less than 3 days to make electrical connections and installing trolleys and controls.

TABLE 6.1 COMPARISON OF LIFTING TECHNIQUES (1)

Item	Description	Bare LCM-8 Lift Beam	LCM-8 Lift Beam w/ Counterweights and Compression Members	LCM-8 Lift Beam w/ Counterweights, Compression Members and Moveable Lift Points	Cantilever Lift Frame With Moveable Lift Points	Jib Boom on Lighter Crane	Pedestal Crane on Lighter Crane	Remarks
1.	Capability							
	Loading/Discharging	Fair	Good	Very Good	Very Good	Excellent	Excellent	
	Stowing	Fair	Good	Very Good	Very Good	Excellent	Excellent	
	Pendulation Control	Fair	Good	Very Good	Very Good	Very Good	Very Good	
	Reliability	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	
	Flotation Stability	Poor	Good	Good	Very Good	Excellent	Excellent	
2.	Cost (Est. in $ K)							
	Acquisition	35	265	315	200	310	635	
	Installation (including ship time over 3 days).	0	10	10	10	555	1125	
	Total	35	275	325	210	865	1760	
3.	Time Requirements							
	Lead Time	(3) Complete	3 mos.	3 mos.	3 mos.	3 mos.	3 mos.	
	Fabrication Time		6 mos.	8 mos.	8 mos.	12 mos.	12 mos.	
	Installation Time		3 days	3 days	3 days	14 days	30 days	
	Total		9 mos.+	11 mos.+	11 mos.+	15.5 mos.	16 mos.	
4.	Extent of Ship Modifications.	None (2)	None (2)	Minimum (3)	Minimum (3)	Extensive (4)	Extensive (4)	

TABLE 6.1 COMPARISON OF LIFTING TECHNIQUES (Continued)

Item	Description	Bare LCM-8 Lift Beam	LCM-8 Lift Beam w/ Counterweights and Compression Members	LCM-8 Lift Beam w/ Counterweights, Compression Members and Moveable Lift Points	Cantilever Lift Frame With Moveable Lift Points	Jib Boom on Lighter Crane	Pedestal Crane on Lighter Crane	Remarks
5.	Expected Commercial applicability	Limited	Fair	Good	Good	Good	Good	
6.	Personnel							
	Special Training required.	None	Some	Some	Some	Extensive	Extensive	
	Number of Personnel for Discharge	19	19	19	19	19	19	
7.	Safety							
	Additional Deck Lighting	Required	Required	Required	Required	Required	Required	
	Additional Communications	Required	Required	Required	Required	Required	Required	
8.	Expected Ship Owner Acceptance	Yes	Probable	Probable	Probable	Doubtful	Doubtful	

See Notes - next sheet.

TABLE 6.1 COMPARISON OF LIFTING TECHNIQUES (Continued)

NOTES:

(1) Some items of comparison apply to the outsize cargo components shown in Table 3.1. The use of the lighter frame alone is considered unsuitable for general outsize cargo.

(2) It is assumed C-8 LASH lighter cranes are modified for off-center loads, like C-9 LASH ships. See Section 2.

(3) Some electrical control and power wiring would be required to implement the moveable lifting points.

(4) Power for the jib and revolving pedestal cranes would be self-contained. Structural modifications including foundations would be required for both cranes.

Cost

The two point lifting beam method consisting of LCM-8 lifting beams and complementary items are:

(2) LCM-8 Lifting Beams	$ 70,000
Counterweight Beam	110,000
Compression Members	35,000
Rail Carriage (compression members)	50,000
Moveable lift points (Add to existing LCM-8 lifting beams)	50,000
Ship modifications, power and controls	10,000
TOTAL	$325,000

Disadvantages

With the most favorable placement of component weights to favor loading frame configuration, there is only one impossible lift with the Alliance Crane involving the P & H 6250 Truck Crane on the 4 x 15 causeway. However, the AMMI Causeway could be used as an alternative.

Limitations on lifting capability has resulted in loading major components to suit the lift resulting in limited freeboard which had to be adjusted for some of the larger outsize components.

6.2 Cantilever Lift Frame With Moveable Lift Points

The cantilever lift frame is perhaps the simplest in scope of all lifting methods. It combines the simplicity and portability of the LCM-8 lifting and compression beams, but has greater operating capability and flexibility,

requiring for example, no counterweights imposed on the cargo component.

Advantages

There are few impossible lifts.

Less vertical height is required than with other methods.

Load components can be placed farther aft to improve trim.

Beam is shallower affecting pendulation.

No counterweight compression members are required.

Cost

Ship modifications, electrical controls	$ 10,000
Cantilever Lift Frame	100,000
Moveable lift points	100,000
TOTAL	$210,000

Disadvantages

Requires the fabrication of new hardware.

6.3 Jib Boom on Lighter Crane

Advantages

The external lift eliminates the need for a counterweight and the complementary compression members.

Eliminating the counterweight permits higher lifting beam loads. With a

rather limited external lift, all outsize components can be lifted, with either the Morgan or Alliance Arrangement.

The employment of an external lift improves handling of outsize components in the stern well, and when stowing on deck.

Placement of major weights aboard the component with regard to center of gravity is not limited as to lift capability, consequently the weight can be placed farther aft, thereby improving trim.

An external lift facility mounted on the LASH gantry may have some commercial value, particularly for those ships without container cranes.

Cost

The jib and boom on lighter crane is obviously more costly than the simpler counterweight method:

Lost Time (14 days @ $45,000	$495,000
Self-Contained Hydraulic Jib Boom and Winch	225,000
LCM-8 Lift Beam	35,000
Erection	50,000
Ship Modifications, Power, Controls	10,000
Moveable Lift Two Point Suspension System (Add to LCM-8 Lifting Beam)	50,000
TOTAL	$865,000

Disadvantages

Requires permission from the Owner to install structural foundation and erect the crane assembly.

Availability of the jib boom and winch arrangement is approximately one year from the date of order. Structural modification and erection of the equipment would require one to two weeks in a shipyard. This, added to the test period, would result in a somewhat longer lease period.

6.4 Revolving Pedestal Crane on Lighter Crane

Advantages

The four point external lift method does not require the LCM-8 lifting beam or the counterweight beam. Instead, this system utilizes an adapter connecting to all four lifting sockets for a conventional symmetrical lift.

All outsize components can be lifted with this method with no restrictions. This method can take advantage of the full lighter crane capacity.

No crane modifications, such as changes in circuitry, overriding of craneway stops or installation of stern well guides, are required.

The external lift permits the operator to guide the component in the stern well and improves orientation of components while stowing on deck.

Greater overall lifting capacity permits placement of loads on the components to achieve desirable freeboard of the loaded component.

The external lift crane would be pedestal type centrally mounted on top of the LASH gantry. The 75 foot boom with jib extension would have sufficient capacity to handle 30 ton containers over either side.

Cost

The four point lift method consisting of the 75 ton revolving crane is the most sophisticated method of handling outsize components, and also the most costly. Factors contributing to the cost are:

Lost Time (25 days @ $45,000)	$1,125,000
Pedestal mounted revolving crane and acquisition cost	350,000 (1)
Structural modifications to gantry and installation	125,000
Ship modifications, power, controls	10,000
LASH Crane Adapter	100,000
Lateral transition devices and two point suspension	50,000
TOTAL	$1,760,000

Disadvantages

Although the external lift crane would have some commercial value, permission must be obtained from the Owner for rather extensive structural modifications to facilitate installation.

Acquisition time for the crane would be at least a year from the date of order. Structural modifications and installation would require three to four weeks in a shipyard.

(1) A pedestal mounted crane may be rented at approximately $25,000.00 per month, depending on prior planning.

7. STOWAGE OF OUTSIZE CARGO COMPONENTS

The stowage of outsize cargo components on the weather deck is ideally suited to the LASH ships due to the high strength factor of the deck structural components. Compared to a green water design rating at 180 lbs. per square foot, the LASH vessels have the following maximum deck load ratings:

Hatch 1a - 1500 lb/ft^2

Hatch 1b - 1500 lb/ft^2

Hatch 1c - 2900 lb/ft^2

Hatch 2b - 2900 lb/ft^2

Hatch 3b - 2900 lb/ft^2

Hatch 4 - 900 lb/ft^2

Hatch 5 - 2200 lb/ft^2

Hatch 6 - 2100 lb/ft^2

Two longitudinal bulkheads are provided port and starboard throughout the entire length of the ship to support the lighter gantry crane rails. Box girders on either side of each hatch are provided to support the hatch, hatch coaming and lighter load castings, and are tied into the longitudinal bulkheads. The 64 foot girders are 3 feet wide and 8 feet deep and have a concentrated safe load beam capacity of 5350 kips.

Under actual commercial loading modes, lighters weighing 1000 kips each are carried 2-high in port and 2-high, one at 1000 kips, and one empty at approximately 174 Kips at sea. Based on the load of two full lighters 2-high, and hatch dimensions of 34'-7" x 63'-11", the deck loading would be 904 lb/ft^2 which is safely within the design range.

A typical stowage configuration without regard to strategic logistics is shown in Figure 7.1. Inasmuch as the bearing load will be imposed on two box girders or the area of one hatch cover supported by two box girders depending on how we chock the components, we will determine the unit loadings of the outsize cargo components for comparison to commercial practice and the maximum allowed by design. Refer to Table 7.1 Calculated unit deck loadings are actually less than the loadings with commercial lighters.

In addition to stowing outside cargo components on deck as shown in Figure 7.1 some components like the 4 x 10 causeway section can be carried within the cargo holds. Pilings, the LCM-6, the bare P & H 6250 Truck Crane without boom and the (2) LARC's are additional items that can be carried athwartship in the cargo holds depending on the number of lighters that might be vital to the mission. In discharging these components, they would be reoriented to a fore and aft direction on deck after removal from the hold for easier discharge in the stern well to floating barges or causeway sections. Maximum inner deck loadings permissible to accommodate hold stowage is as follows:

Hatch 2b - 2900 lb/ft^2

Hatch 3b - 2900 lb/ft^2

Hatch 4b - 2900 lb/ft^2

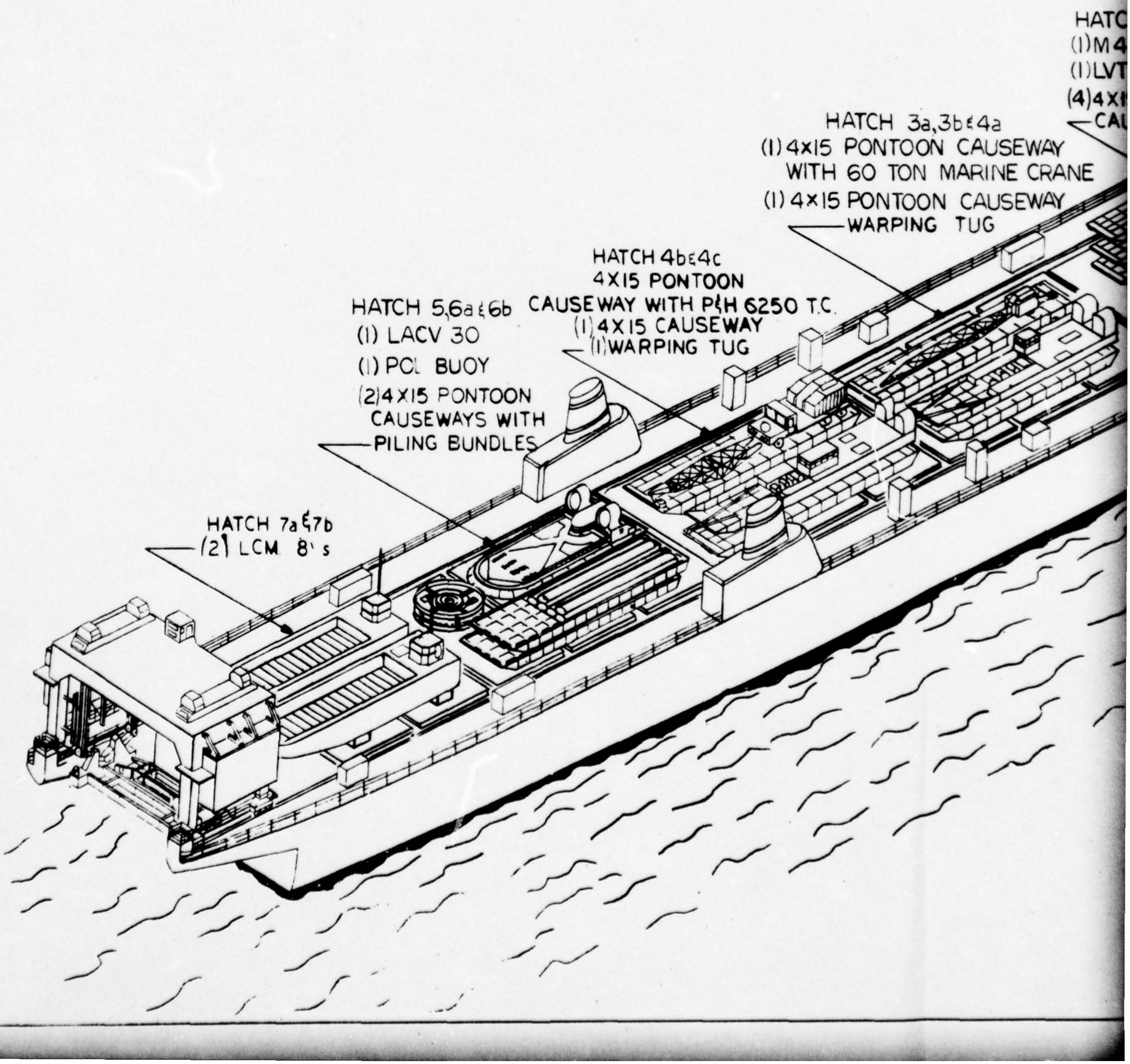
Hatch 5a - 900 lb/ft^2

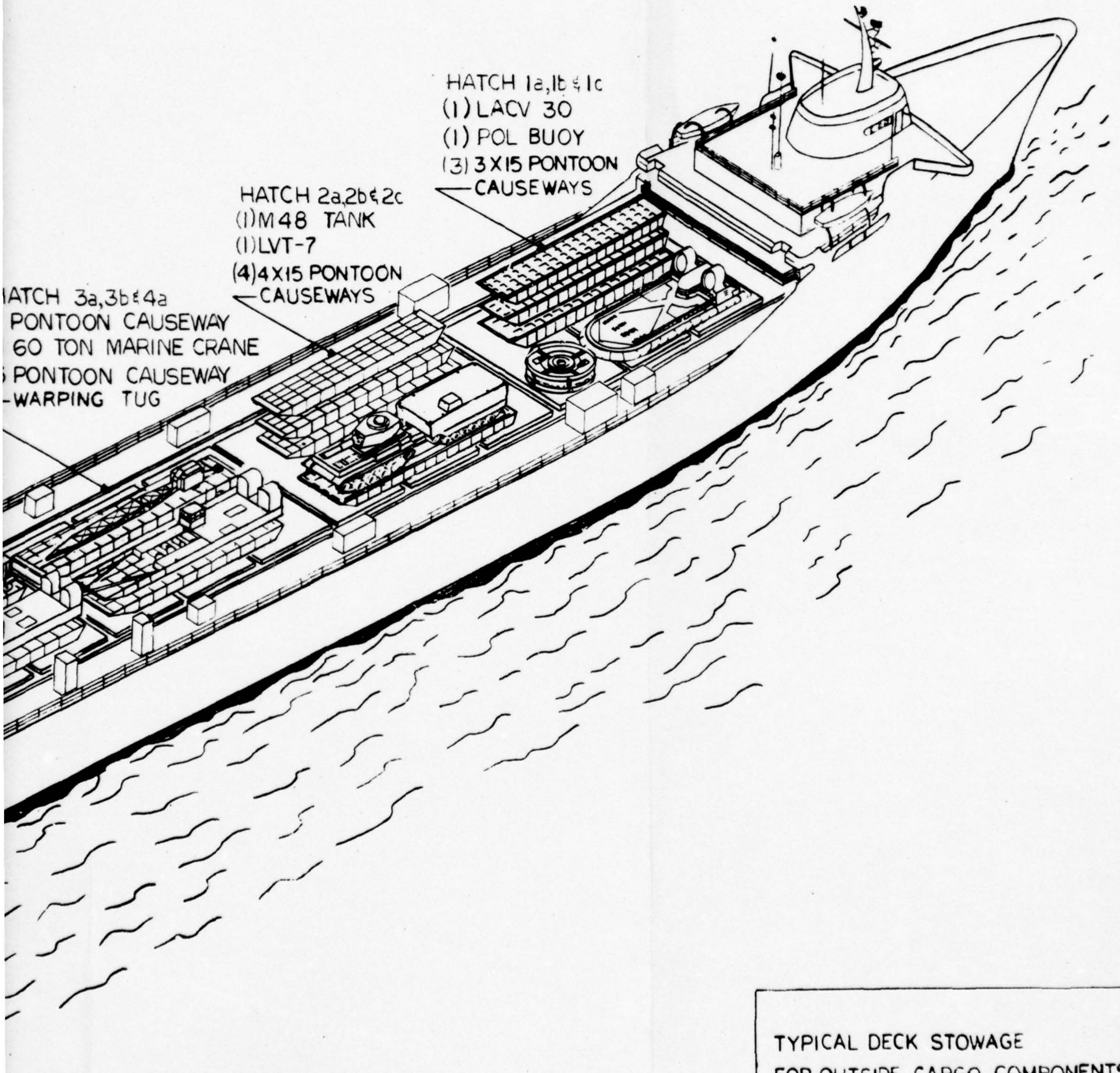
Hatch 6b - 2200 lb/ft^2

Hatch 7b - 2100 lb/ft^2

7.1 Tie-down and Chocking Arrangement

Existing tie-down arrangement consists of D-rings recessed into the box girders between the hatches, for tieing down lighters. Deck sockets in the hatch


HATC
(1)M4
(1)LVT
(4)4X1
CAL
HATCH 3a,3b & 4a
(1) 4X15 PONTOON CAUSEWAY
WITH 60 TON MARINE CRANE
(1) 4X15 PONTOON CAUSEWAY
WARPING TUG
HATCH 4b & 4c
4X15 PONTOON
CAUSEWAY WITH P&H 6250 T.C.
(1) 4X15 CAUSEWAY
(1) WARPING TUG
HATCH 5,6a & 6b
(1) LACV 30
(1) POL BUOY
(2) 4X15 PONTOON
CAUSEWAYS WITH
PILING BUNDLES
HATCH 7a & 7b
(2) LCM 8's



TYPICAL DECK STOWAGE
FOR OUTSIDE CARGO COMPONENTS
FOR C-9 LASH VESSEL

FIGURE 7.1

TABLE 7.1 HATCH LOADINGS FOR OUTSIZE CARGO

Location	Cargo Components	Weight Kips	Bearing[(1)] Area Sq. Ft.	Unit Loading Lb/Ft^2	Remarks
Hatch 1a, 1b & 1c	(1) LACV - 30 (3) 3 x 15 Pontoon Causeways (1) Pol Buoy	300 411 300	2210	457	
Hatch 2a, 2b & 2c	(1) M-48 Tank (4) 4 x 15 Pontoon Causeways (1) LVT-7	96 732 70	2210	406	
Hatch 3a, 3b & 4a	(1) 4 x 15 Causeway with 60 Ton Marine Crane (1) 4 x 15 Causeway (1) Warping Tug	301 183 194	2210	306	Note 2.
Hatch 4b & 4c	(1) 4 x 15 Causeway with P & H 6250 Truck Crane (1) 4 x 15 Causeway (1) Warping Tug	419 183 194	2210	360	Note 2.
Hatch 5, 6a & 6b	(1) LACV-30 (2) 4 x 15 Pontoon Causeways with Bundles of Piling. (1) Pol Buoy	300 403 300	2210	454	
Hatch 7a & 7b	(2) LCM-8's	268	2210	121	

NOTE 1: The unit area is based upon one hatch only. Calculations are based upon placing chocks upon the hatch covers so the load is carried by (2) box girders.
NOTE 2: Vertical clearance is 23'-9". Refer to Figure 4.6.

covers are available to serve those ships that carry containers as deck cargo. The container deck sockets are too light to secure the causeway components and it is recommended to use only the lighter tie-down fittings attached to box girders and wing walls. Some of the D-rings may not be in the right location for securing outsize cargo and there may be an insufficient number on existing ships, so it is likely that more will have to be added. Padeyes will also have to be added to many of the outsize components. All tie-down hardware, consisting of padeyes, wire rope, turnbuckles and D-rings shall be suitable for Sea State 9 conditions, and shall meet Coast Guard and ABS requirements. Details of the tie-down arrangement and the location of deck fittings shall be part of the loading manual and shall be completed as a part of Phase 2.

The chocks used to absorb the bearing loads shall consist of choice timbers, contoured as required to conform to the LASH deck and the bearing surfaces of the outsize cargo components. Chocks can either be placed on the hatch cover adjacent to the hatch coaming so that the component load spans two box girders which absorb most of the load. A second method is to place the chocks directly on the girders themselves so that the cargo components do not touch the hatch cover. By this method, it would be virtually impossible to do any damage to the hatch cover. When components are stacked such as the (3) 4 x 15 pontoon causeways in the illustration, chocks are placed between them to cushion the bearing surfaces.

7.2 Hatch Covers

Facilities to open the hatch covers varies with the different LASH ships. The forward hatch for those ships that carry containers forward folds and is hydraulically operated. Others can be lifted off with the container gantry

where they are available. For the lighter holds, hatch covers are fitted with lifting sockets that conform to the lighter gantry lift frame. Approximate weights of the hatch covers are as follows:

Hatch Number	Weight (Kips)
1a	164.0
1b & 1c	116.8
2 & 3	115.6
4, 5, 6 & 7	114.6

Stowage of hatch covers during cargo discharge operations is really no problem. After the deck stowed outsize cargo components are removed, the gantry lighter crane lifts off the cargo hatch covers and merely deposits the hatch cover on an adjacent hold.

8. ELECTRICAL POWER AND CONTROL MODIFICATIONS

By Navy standards, the LASH ships are not overly abundant with ship's service electrical power. Sufficient power is available to support the requirements of a LAPS test mission, considering all lifting techniques, but not for an extended operational assignment in a military environment.

Some pertinent facts taken from Table 2.1 - Principal Characteristics of U. S. Flag Ships, are as follows:

	Class LASH Ships	
Generator Capacity	C-8	C-9
(1) Ship's Service Generator	2500 KW	2000 KW
(1) Auxiliary Diesel	2000 KW	2000 KW
(1) Emergency Diesel	250 KW	250 KW
Generator Load Analysis		
Maximum Sea Load	2200 KW	1850 KW
Maximum Port Load	1600 KW	1206 - 3020 KW

With the C-9 LASH ships, there appears to be considerable disparity with the maximum port load.

The execution of a LAPS Mission which by understanding would dictate a hostile environment and require sea-going capability while accomplishing an advanced port function, would by Navy standards require an additional ship's service generator. The additional service generator could be mounted on deck in a specially designed module.

Additional power and control wiring would be required depending on the lifting

technique that is selected. The moveable lift points would require power to move the trolleys, and control wiring to a control station preferably located in the gantry operator's control cab, or to a separate control station.

Additional deck lighting would be required to support the discharge of cargo at night. Additional sound powered telephones would be required to establish suitable communications between the control station, the lines crew and the point of discharge.

9. PERSONNEL REQUIREMENTS

Most of the LASH ships have accommodations for (12) military personnel. With a limited degree of training and the assistance of several crew members, these personnel should be sufficient to man the LAPS Mission.

It is envisioned that personnel would be assigned to the following tasks:

9.1 Stowage of Outsize Cargo Components

(4) Riggers and (1) Signalman would be required.

This crew would guide the components to their proper stowage position according to the loading plan. The riggers would place the chocks and adjust the tie-down lines after disengaging the lift from the lighter gantry.

During discharge operations, the riggers would hook up the load using the proper slings, disengage tie-down lines and remove the chocks.

The signalman would coordinate operations with the crane operator.

9.2 Intraship Movement

(4) Riggers and (1) Deck Cargo Officer would be required.

The riggers would man the taglines either manually or by utilizing the constant tension winches on the wing walls, as the cargo component moves during loading and discharge operations.

The deck cargo officer would coordinate the guidance operations with the crane operator.

9.3 Crane Operations

(2) Crane Operators and (1) Signalman would be required.

A principal operator and assistant should be available to operate the lighter gantry and complementary items such as moveable lifting points on the LCM-8 lifting and counterweight beams, or the jib boom and revolving pedestal crane depending on which technique is selected.

The signalman is the principal coordinator between the crane operator and deck and sternwell personnel during loading and discharge operations.

9.4 Launching

(6) Riggers would be required.

The riggers would handle the barge handling winches and taglines manually to control pendulation of the cargo component while it is being raised or lowered in the stern well.

Although not part of the LASH crew, the tug crew consists of an operator, a signalman and a crew of two to handle lines. The primary function of the tug crew is to remove the outsize cargo component from the stern well and to propel the component to its causeway destination.

In summation, a total number of 19 LASH personnel are required to conduct the LAPS Mission. If the additional personnel cannot be furnished from civilian crew members, additional accommodations would be required for the seven additional Navy personnel. An accommodation module could be stowed on deck aft of the deckhouse for this purpose.

10. SAFETY

All structural hardware contributing to the different lifting techniques, the tie-down arrangement and deck fittings shall conform to ABS, Coast Guard and Navy standards. Operating procedures for the handling of outsize cargo components during loading and discharge modes shall meet Occupational Safety and Health Administration (OSHA) requirements.

It is suggested that a detailed safety and maintenance analysis be conducted on all proposed LAPS equipment and that specific recommendations be developed for operational procedure, design changes, maintenance policy and possible redundancy or back-up operational modes. This will ensure the best reliability, maintainability and operational safety of all subsystems.

As in the case of Navy ships, the LASH ships as applied to the LAPS Mission must be self-sufficient to perform all tasks safely and reliably. This will require an expansion of onboard maintenance and operational skills and facilities; so that all subsystems can be adjusted, repaired and tested without dependency on shore facilities. System Operability Tests (SOT's) should be planned and implemented for each subsystem and each piece of equipment making up the LAPS configuration.

The safety of operating personnel depends on certain operational cycle times. For example, the following dwell times are applicable to safe crane operation:

- o The hook load-on time should not exceed 10 seconds.
- o To change the path of the load should not exceed 4 seconds.
- o Landing and unhooking the load manually should not exceed 6 seconds.

Total impact load, static and dynamic, when stowing a component on deck or launching a component in the stern well shall not exceed 2 g's or twice the weight of the component.

Adequate deck lighting and interior communications shall be furnished to permit the loading and discharge of outsize cargo at night.

The strength of tie-down and deck lifting components shall be suitable dynamically for a ship's roll of 30 degrees in either direction, a heave of 6 feet, a pitch of 6 degrees up and down and a wind pressure on the cargo component areas of 30 lbs. per square foot.

11. PENDULATION CONTROL

The LAPS equipment shall be capable of loading and discharging outsize cargo components without shoreside assistance in a Sea State 3 environment. Discharge will occur with pendulation induced by LASH ship motions imposed by a quartering, 5-foot, 12 second sea, as the upper operating limit. It will also be desirable, but not imperative, to recover outsize cargo components in the same sea environment.

Estimated LASH load frame motion in a Sea State 3 is shown in the following tabulation (induced in a C-9 LASH with a 5-foot quartering sea at 12 second period). The ship's roll is 0.5 degrees at 12 second period.

	Displacement Ft.	Velocity Ft./Sec.	Acceleration Ft./Sec.^{2}
Vertical	3.9	2.1	1.1
Longitudinal	0.2	0.1	0.1
Transverse	2.6	1.4	0.7

One of the distinguishing features of the LASH lighter are the swell compensators incorporated within the crane load frame to compensate for up to 8 feet of relative vertical displacement between the load frame and the cargo component.

Pendulation is minimized by the single component lift concept. Unlike the original LCM-8 lifting concept which proposed to lift two units simultaneously, all lifting techniques propose to lift or lower one component at a time on the centerline of the stern well. This provides greater side clearance in the stern well, improves handling capability and obviates the requirement of well guides.

Lifting slings shall be configured with minimum vertical height to reduce

swing. A typical lifting arrangement for a pontoon causeway will consist of a port and starboard sling, each connecting two side padeyes to a different lifting point on the lifting beam or adapter. The athwartship distance between the lifting points can be adjusted to be slightly greater than the beam of the cargo component. Suspending the component weight from two spread lifting points induces port and starboard lateral components of force to decrease the tendency of the load to pendulate.

When the counterweight beam and vertical compression members are used, the bearing area against the cargo component is sufficiently great so that some rigidity between the component and the counterweight beam results, tending to reduce pendulation.

As the cargo component moves longitudinally along the LASH during loading and discharge operations, taglines will be used to guide the component and control pendulation. The taglines will either be handled manually by the riggers on deck, or by employing the constant tension winches mounted on the wing walls of the LASH.

In lowering or lifting the cargo component in the stern well, taglines can be manned by the launch riggers or the barge handling winches may be utilized.

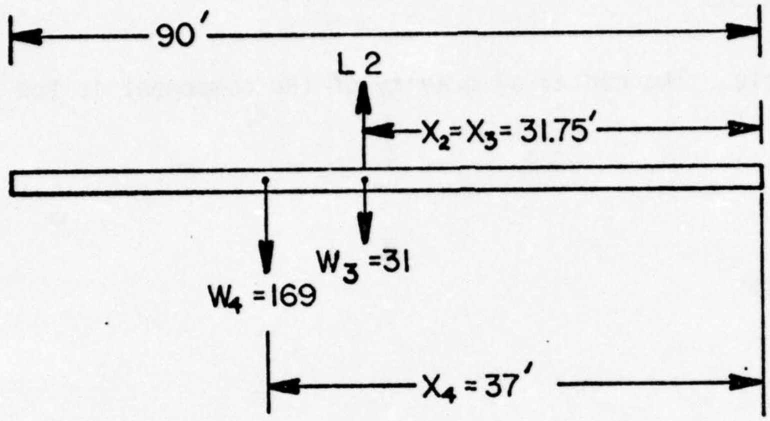
APPENDIX "A"

CALCULATIONS FOR LCM-8 BEAM BARE

WITHOUT COUNTERWEIGHTS

1. LCM-8 BEAM BARE - MORGAN ARRANGEMENT

Sketch A-1



W_3 = Weight of LCM=8 Beam

W_4 = Weight of Cargo Component

L_2 = Lift at Aft Sockets of Lighter Frame

Sketch A-1 applies to the following calculations;

Item 6

$X_4 = 90 - 53 = 37'$

$X_4 > X_2$

Therefore the center of gravity is too far aft. The component cannot be lifted without a counterweight.

ALLIANCE ARRANGEMENT

Lift is impossible. Center of gravity of component is too far aft.

Item 7

$W_4 = 194$ Kips

$X_4 = 90 - 51 = 39'$

$X_4 > X_2$

Therefore, the center of gravity is too far aft. The component cannot be lifted without a counterweight.

ALLIANCE ARRANGEMENT

Lift is impossible. The center of gravity of the component is too far aft.

Item 8a

W_4 = 227 Kips

X_4 = 91 - 52 = 39'

$X_4 > X_2$

Therefore, the center of gravity is too far aft. The component cannot be lifted without a counterweight.

ALLIANCE ARRANGEMENT

Lift is impossible. Center of gravity of the component is too far aft.

Item 8b

W_4 = 230 Kips

X_4 = 91.7 - 53 = 38.7'

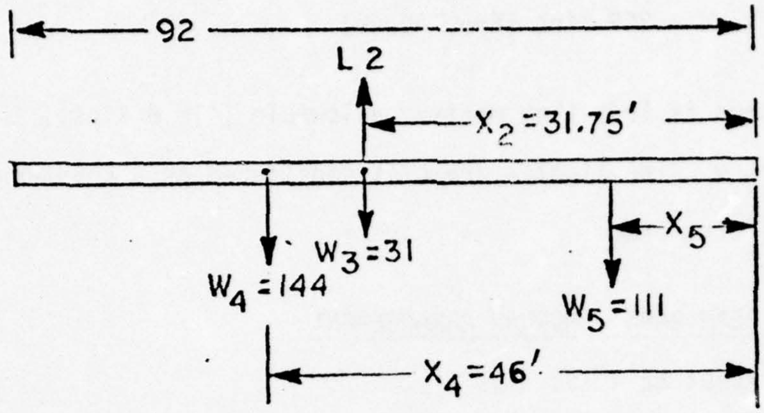
$X_4 > X_2$

Therefore, the center of gravity is too far aft. The component cannot be lifted without a counterweight.

ALLIANCE ARRANGEMENT

Lift is impossible. Center of gravity of the component is too far aft.

2. ITEM 11b - LCM-8 BEAM BARE - MORGAN ARRANGEMENT



$X_5 \geq 11'$

L_2 = Lift Frame Load @ Aft Sockets

W_3 = Weight of LCM-8 Beam

W_4 = Weight of Causeway

W_5 = Weight of Crane (MK-100)

$\Sigma F_y = 0 = W_4 + W_3 - L_2 + W_5 = 0$

$L_2 + W_4 + W_3 + W_5 = 144 + 31 + 111 = 286$ Kips

Beam Load = $L_2 - W_3 = 286 - 31 = 255$ Kips

$\Sigma M_{\text{end of causeway}} = 0 = W_4 X_4 + W_3 X_3 - L_2 X_2 + W_5 X_5 = 0$

$$X_5 = \frac{L_2 X_2 - W_4 X_4 - W_3 X_3}{W_5}$$

$$X_5 = \frac{286 (31.75) - 144 (46) - 31 (31.75)}{111} = 13.26'$$

Lift OK W/Morgan Crane ($X_5 > 11'$)

ALLIANCE ARRANGEMENT

Beam Load = 255 Kips (From Above)

Beam load of 255 Kips is less than maximum allowable (416.6 Kips), therefore Alliance is satisfactory. The lighter frame is considered as a counterweight for equilibrium of the lifting frame.

3. ITEM 11c - LCM-8 BEAM BARE - MORGAN ARRANGEMENT

Same as Item 11b except W_4 = 190 Kips

$$\Sigma F_y = 0 = W_4 + W_3 - L_2 + W_5 = 0$$

$$L_2 = W_4 + W_3 + W_5 = 190 + 31 + 111 = 332 \text{ Kips}$$

$$\text{Beam Load} = L_2 - W_3 = 332 - 31 = 301 \text{ Kips}$$

$$\Sigma M_{\text{end of causeway}} = 0 = W_4 X_4 + W_3 X_3 - L_2 X_2 + W_5 X_5 = 0$$

$$X_5 = \frac{L_2 X_2 - W_4 X_4 - W_3 X_3}{W_5} = \frac{332\ (31.75) - 190\ (46) - 31\ (31.75)}{111}$$

$$X_5 = 7.36$$

Since X_5 must be $\geq$ 11', solution is unsatisfactory. Alliance Crane is also unsatisfactory.

4. ITEM 11d - LCM-8 BEAM BARE - MORGAN/ALLIANCE ARRAMGEMENTS

With either orientation of 4 x 10 causeway, its center of gravity is within load frame. Put center of gravity of crane at center of gravity of causeway w/boom facing aft. Using 2 beams (LCM-8), no problem with either crane.

Beams share load, yet either is capable of entire load. No moment problem, since center of gravity is within lighter frame.

5. ITEM 11e - LCM-8 BEAM BARE - MORGAN ARRANGEMENT

Same as Item 11b except W_4 = 110 Kips and X_4 = 45'

$$\Sigma F_y = 0 = W_4 + W_3 - L_2 + W_5 = 0$$

$$L_2 = W_4 + W_3 + W_5 = 110 + 31 + 111 = 252 \text{ Kips}$$

$$\text{Beam Load} = L_2 - W_3 = 252 - 31 = 221 \text{ Kips}$$

$$\Sigma M_{\text{end of causeway}} = 0 = W_4 X_4 + W_3 X_3 - L_2 X_2 + W_5 X_5 = 0$$

$$X_5 = \frac{L_2 X_2 - W_4 X_4 - W_3 X_3}{W_5} = \frac{252\ (31.75) - 110\ (45) - 31\ (31.75)}{111}$$

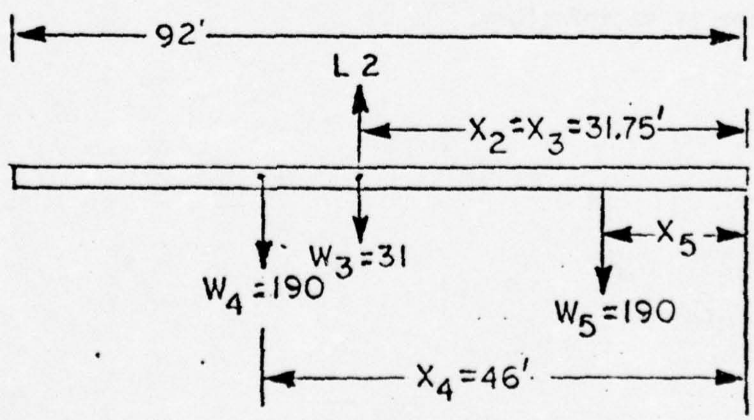
X_5 = 18.62; $X_5 > 11'$ - therefore the solution is OK

ALLIANCE ARRANGEMENT

Beam Load = 221 Kips (From Above)

Beam load of 221 Kips is less than maximum allowable value of 416.6 Kips. Therefore, Alliance Crane is satisfactory.

6. ITEM 12c - LCM-8 BEAM BARE - MORGAN ARRANGEMENT



L_2 = Lift at Lighter Frame Aft Sheaves

W_3 = Weight of LCM-8 Lift Beam

W_4 = Weight of Causeway

W_5 = Weight of P & H 9125 Crane

$X_5 \geq 15'$

$$\Sigma F_y = W_4 + W_3 - L_2 + W_5 = 0$$

$$L_2 = W_4 + W_3 + W_5 = 411 \text{ Kips}$$

$$\text{Beam Load} = L_2 - W_3 = 411 - 31 = 380 \text{ Kips}$$

$$\Sigma M_{\text{end of causeway}} = W_4 X_4 + W_3 X_3 - L_2 X_2 + W_5 X_5 = 0$$

$$X_5 = \frac{L_2 X_2 - W_4 X_4 - W_3 X_3}{W_5} = \frac{411 (31.75) - 190 (46) - 31 (31.75)}{190}$$

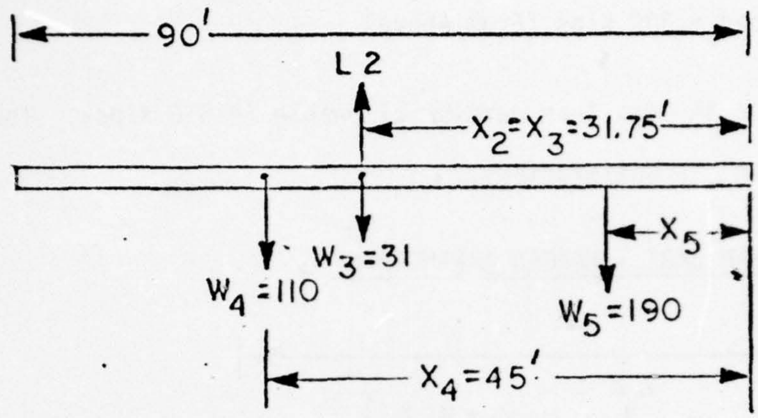
$X_5 = 17.50'$; $X_5 > 15$ - therefore Morgan Crane is satisfactory

ALLIANCE ARRANGEMENT

Beam Load = 380 Kips (From Above)

Beam load of 380 Kips is less than maximum allowable value of 416.6 Kips. Therefore, Alliance Crane is satisfactory.

8. ITEM 12d - LCM-8 BEAM BARE - MORGAN ARRANGEMENT



L_2 = Lift at Lighter Frame Aft Sheaves

W_4 = Weight of Causeway

W_3 = Weight of Lift Beam

W_5 = Weight of P & H 9125 Crane

$X_5 \geq 15'$

$$\Sigma F_y = 0 = W_4 + W_3 - L_2 + W_5 = 0$$

$$L_2 = W_4 + W_3 + W_5 = 331 \text{ Kips}$$

$$\text{Beam Load} = L_2 - W_3 = 331 - 31 = 300 \text{ Kips}$$

$$\Sigma M_{\text{end of causeway}} = 0 = W_4 X_4 + W_3 X_3 - L_2 X_2 + W_5 X_5 = 0$$

$$X_5 = \frac{L_2 X_2 - W_4 X_4 - W_3 X_3}{W_5}$$

$$X_5 = \frac{331 (31.75) - 110 (45) - 31 (31.75)}{190} = 24.08'$$

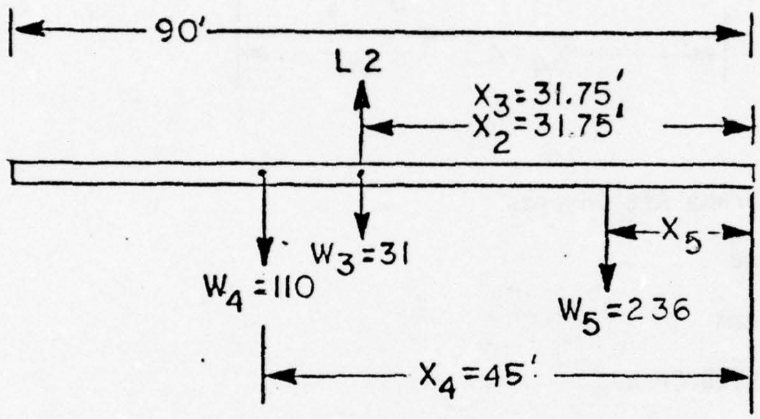
$X_5 > 15'$ - therefore Morgan Arrangement is satisfactory

ALLIANCE ARRANGEMENT

Beam Load = 300 Kips (From Above)

Beam load of 300 Kips is less than maximum allowable (416.6 Kips). Therefore Alliance Arrangement is satisfactory.

9. ITEM 13e - LCM-8 BEAM BARE - MORGAN ARRANGEMENT



L_2 = Lift at Aft Sheaves of Lighter Frame

W_3 = Weight of LCM-8 Beam

W_4 = Weight of AMMI Causeway

W_5 = Weight of P & H 6250 Crane

$X_5 \geq 17'$

$\Sigma F_y = W_4 + W_3 - L_2 + W_5 = 0$

$L_2 = W_4 + W_3 + W_5 = 110 + 31 + 236 = 377$ Kips

Beam Load = $L_2 - W_3 = 377 - 31 = 346$ Kips

$\Sigma M_{\text{end of causeway}} = W_4 X_4 + W_3 X_3 - L_2 X_2 + W_5 X_5 = 0$

$$X_5 = \frac{L_2\ X_2 - W_4\ X_4 - W_3\ X_3}{W_5} = \frac{377\ (31.75) - 110\ (45) - 31\ (31.75)}{236}$$

$X_5 = 25.57'$

$X_5 > 17'$ - therefore Morgan Crane is satisfactory

ALLIANCE ARRANGEMENT

Beam Load = 346 Kips (From Above)

Beam load of 346 Kips is less than maximum allowable (416.6 Kips). Therefore Alliance Arrangement is satisfactory.

APPENDIX "B"

CALCULATIONS FOR LCM-8 LIFTING BEAM

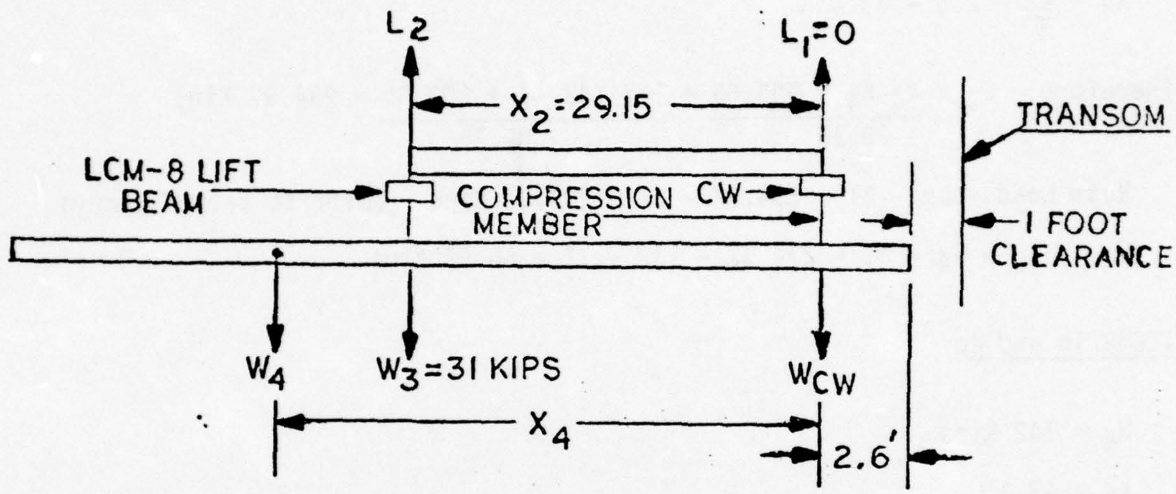
WITH COUNTERWEIGHTS AND COMPRESSION MEMBERS

OUTSIZE CARGO COMPONENT DISCHARGE CAPABILITY

1. LCM-8 LIFTING BEAM w/COUNTERWEIGHTS

MORGAN ARRANGEMENT

Sketch B-1



$L_1 = 0$

$X_x = X_3 = 29.15'$

$L_2 \geq 447.6$

X_4 = 1/2 Component Length - 2.6

W_4 = Weight of Component

L_2 = Required Lift

Beam Load = $L_2 - W_3 = L_2 - 31$

$$\Sigma F_y = 0 = W_4 + W_3 + W_{CW} - L_1 - L_2 = 0$$

$$W_{CW} = L_2 - W_4 - 31$$

$$\Sigma M_{CW} = 0 = W_4 X_4 + W_3 X_3 - L_2 X_2 = 0$$

$$W_4 X_4 + 31 (29.15) - 29.15 L_2 = 0$$

$$L_2 = \frac{W_4 X_4 + 903.65}{29.15}$$

Sketch B-1 applies to the following calculations:

ITEM 1a

W_4 = 137 Kips

$X_4 = \frac{92}{2} - 2.6 - 43.4'$

Therefore: $L_2 = \frac{W_4 X_4 + 903.65}{29.15} = \frac{137 (43.4) + 903.65}{29.15} = 234.97$ Kips

Beam Load = L_2 - 31 = 234.97 - 31 = 203.97 Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 234.97 - 137 - 31 = 66.97$ Kips

ITEMS 1b and 1c

W_4 = 142 Kips

X_4 = 43.4'

Therefore: $L_2 = \frac{W_4 X_4 + 903.65}{29.15} = \frac{142 (43.4) + 903.65}{29.15} = 242.42$ Kips

Beam Load = L_2 - 31 = 242.42 - 31 = 211.42 Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 242.42 - 142 - 31 = 69.42$ Kips

ITEM 1d

W_4 = 144 Kips

X_4 = 43.4'

Therefore: $L_2 = \frac{W_4 X_4 + 903.65}{29.15} = \frac{144 (43.4) + 903.65}{29.15} = 245.39$

Beam Load = L_2 - 31 = 245.39 - 31 = 214.39 Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 245.39 - 144 - 31 = 70.39$ Kips

ITEM 2a

W_4 = 183 Kips

X_4 = 43.4'

Therefore: $L_2 = \dfrac{W_4 X_4 + 903.65}{29.15} = \dfrac{183\ (43.4) + 903.65}{29.15} = 303.46$ Kips

Beam Load = L_2 - 31 = 303.46 - 31 = 272.46 Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31$ = 303.46 - 183 - 31 = 89.46 Kips

ITEMS 2b and 2c

W_4 = 188 Kips

X_4 = 43.4'

Therefore: $L_2 = \dfrac{W_4 X_4 + 903.65}{29.15} = \dfrac{188\ (43.4) + 903.65}{29.15} = 310.90$ Kips

Beam Load = L_2 - 31 = 310.90 - 31 = 279.90 Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31$ = 310.90 - 188 - 31 = 91.90 Kips

ITEMS 2d and 2e

W_4 = 190 Kips

X_4 = 43.4'

Therefore: $L_2 = \dfrac{W_4 X_4 + 903.65}{29.15} = \dfrac{190\ (43.4) + 903.65}{29.15} = 313.88$ Kips

Beam Load = L_2 - 31 = 313.88 - 31 = 282.88 Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31$ = 313.88 - 190 - 31 = 92.88 Kips

ITEM 3a

W_4 = 122 Kips

X_4 = 1/2 (61'-1") - 2.6 = 1/2 (61.08) - 2.6 = 27.94'

Therefore: $L_2 = \dfrac{W_4 X_4 + 903.65}{29.15} = \dfrac{122\ (27.94) + 903.65}{29.15} = 147.94$ Kips

Beam Load = $L_2 - 31 = 147.94 - 31 = 116.94$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 147.94 - 122 - 31 = -5.06$ Kips

No counterweight is required. A lift of 5 Kips is required @ L_1.

ITEM 3b

$W_4 = 137$ Kips

$X_4 = 27.94'$

Therefore: $L_2 = \dfrac{W_4 X_4 + 903.65}{29.15} = \dfrac{137\ (27.94) + 903.65}{29.15} = 162.31$ Kips

Beam Load = $L_2 - 31 = 162.31 - 31 = 131.31$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 162.31 - 137 - 31 = -5.69$ Kips

No counterweight is required. A lift of 5.7 Kips is required @ L_1.

ITEM 3c

$W_4 = 127$ Kips

$X_4 = 27.94$ Kips

Therefore: $L_2 = \dfrac{W_4 X_4 - 903.65}{29.15} = \dfrac{127\ (27.94) + 903.65}{29.15} = 152.73$ Kips

Beam Load = $L_2 - 31 = 152.73 - 31 = 121.73$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 152.73 - 127 - 31 = -5.27$ Kips

No counterweight is required. A lift of 5.3 Kips is required @ L_1.

ITEM 4

$W_4 = 110$ Kips

$X_4 = \dfrac{90}{2} - 2.6 = 42.4'$

Therefore: $L_2 = \frac{W_4 X_4 + 903.65}{29.15} = \frac{110 (42.4) + 903.65}{29.15} = 191$ Kips

Beam Load = $L_2 - 31 = 191 - 31 = 160$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 191 - 110 - 31 = 50$ Kips

ITEM 6

$W_4 = 169$ Kips

$X_4 = 37 - 2.6 = 34.4$

Therefore: $L_2 = \frac{W_4 X_4 + 903.65}{29.15} = \frac{169 (34.4) + 903.65}{29.15} = 230.43$ Kips

Beam Load = $L_2 - 31 = 230.43 - 31 = 199.43$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 230.43 - 169 - 31 = 30.43$

ITEM 7

$W_4 = 194$ Kips

$X_4 = 36.4'$

Therefore: $L_2 = \frac{W_4 X_4 + 903.65}{29.15} = \frac{194 (36.4) + 903.65}{29.15} = 273.25$ Kips

Beam Load = $L_2 - 31 = 273.25 - 31 = 242.25$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 273.25 - 194 - 31 = 48.25$ Kips

ITEM 8a

$W_4 = 227$ Kips

$X_4 = 39 - 2.6 = 36.4$

Therefore: $L_2 = \frac{W_4 X_4 + 903.65}{29.15} = \frac{227 (36.4) + 903.65}{29.15} = 314.45$ Kips

Beam Load = $L_2 - 31 = 314.45 - 31 = 283.45$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 314.45 - 227 - 31 = 56.45$ Kips

ITEM 8b

$W_4 = 230$

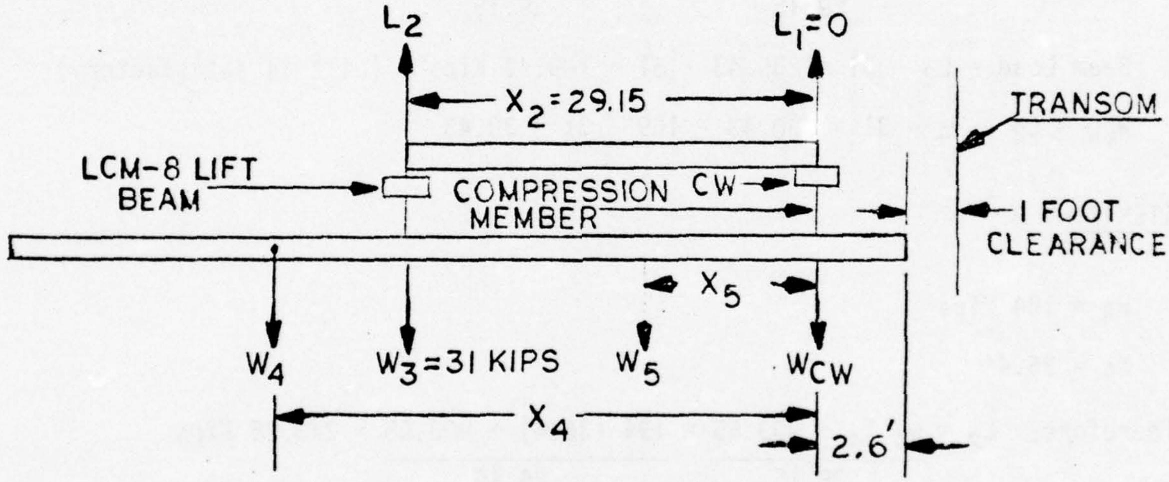
$X_4 = 38.66 - 2.6 = 36.06$

Therefore: $L_2 = \dfrac{W_4 X_4 + 903.65}{29.15} = \dfrac{230\ (36.06) + 903.65}{29.15} = 315.52$ Kips

Beam Load = $L_2 - 31 = 315.52 - 31 = 284.52$ Kips - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - 31 = 315.52 - 230 - 31 = 54.52$ Kips

Sketch B-2



$$\Sigma F_y = 0 = W_4 + W_3 + W_5 + W_{CW} - L_1 - L_2 = 0$$

$$W_{CW} = L_2 - W_4 - W_3 - W_5$$

$$\Sigma M = 0 = W_4 X_4 + 31\ (29.15) + W_5 X_5 - 29.15\ L_1 = 0$$

$$L_2 = \frac{W_4 X_4 + 903.65 + W_5 X_5}{29.15}$$

Sketch B-2 applies to the following calculations:

ITEM 11b

$W_4 = 144$

$W_5 = 111$

$X_4 = \frac{92}{2} - 2.6 = 43.4$

$X_5 = 11$

$$L_2 = \frac{W_4 X_4 + 903.65 + W_5 X_5}{29.15}$$

$$L_2 = \frac{43.4 (144) + 903.65 + (11) (111)}{29.15} = 287.28$$

Beam Load = L_2 - 31 = 256.28 - (Lift is satisfactory)

$W_{CW} = L_2 - W_4 - W_3 - W_5$

$W_{CW} = 287.28 - 144 - 31 - 111 = 1.28$

ITEM 11c

$W_4 = 190$

$W_3 = 31$

$W_5 = 111$

$$L_2 = \frac{W_4 X_4 + 903.65 + (11) (111)}{29.15}$$

$$L_2 = \frac{43.4 (190) + 903.65 + (11) (111)}{29.15}$$

$$L_2 = \frac{8246 + 903.65 + 1221}{29.15} = 355.7$$

Beam Load = 355.7 - 31 = 324.7 - (Lift is satisfactory)

$W_{CW} = 355.7 - 190 - 31 - 111 = 23.7$

ITEM 11d

$W_4 = 127$

$W_3 = 31$

$W_5 = 111$

$$L_2 = \frac{43.4\ (127) + 903.65 + (11)\ (111)}{29.15}$$

$$L_2 = \frac{5511.8 + 903.65 + 1221}{29.15}$$

$$L_2 = \frac{7636.45}{29.15} = 261.97$$

Beam Load = 261.97 - 31 = 230.97 - (Lift is satisfactory)

$W_{CW} = 261.97 - 127 - 31 - 111 = 7.03$

ITEM 11e

$W_4 = 110$

$W_3 = 31$

$W_5 = 111$

$$L_2 = \frac{43.4\ (110) + 903.65 + (11)\ (111)}{29.15}$$

$$L_2 = \frac{4774 + 903.65 + 1221}{29.15}$$

$$L_2 = \frac{6898.65}{29.15} = 236.66$$

Beam Load = 236.66 - 31 = 205.66 - (Lift is satisfactory)

$W_{CW} = 236.66 - 110 - 31 - 111 = 15.34$

ITEM 12b

$W_4 = 137$

$W_3 = 31$

$W_5 = 190$

$X_5 = 15$

$$L_2 = \frac{43.4\ (137) + 903.65 + 15\ (190)}{29.15}$$

$$L_2 = \frac{5945.8 + 903.65 + 2850}{29.15}$$

$$L_2 = \frac{9699.45}{29.15} = 332.74$$

Beam Load = 332.74 - 31 = 301.74 - (Lift is satisfactory)

$W_{CW} = 332.74 - 137 - 31 - 190 = 25.26$

ITEM 12c

$W_4 = 190$

$W_3 = 31$

$W_5 = 190$

$$L_2 = \frac{43.4\ (190) + 903.65 + 15\ (190)}{29.15}$$

$$L_2 = \frac{8246 + 903.65 + 2850}{29.15}$$

$$L_2 = \frac{11999.65}{29.15} = 411.65$$

Beam Load = 411.65 - 31 = 380.65 - (Lift is satisfactory)

$W_{CW} = 411.65 - 31 - 190 - 190 = 0.65$

ITEM 12d

$W_4 = 110$

$W_3 = 31$

$W_5 = 190$

$X_4 = 42.4$

$$L_2 = \frac{42.4\ (110) + 903.65 + (190)\ (15)}{29.15}$$

$$L_2 = \frac{4664 + 903.65 + 2850}{29.15}$$

$$L_2 = \frac{8417.65}{29.15} = 288.77$$

Beam Load = 288.77 - 31 = 257.77 - (Lift is satisfactory)

W_{CW} = 288.77 - 31 - 110 - 190 = 42.23

ITEM 13c

$W_4 = 183$

$W_3 = 31$

$W_5 = 236$

$X_5 = 17'$

$$L_2 = \frac{43.4\ (183) + 903.65 + 17\ (236)}{29.15}$$

$$L_2 = \frac{7942.2 + 903.65 + 4012}{29.15}$$

$$L_2 = \frac{12857.65}{29.15} = 441.08$$

Beam Load = 441.08 - 31 = 410.08 - (Lift is satisfactory)

W_{CW} = 441.08 - 31 - 183 - 236 = -8.92

This item requires a lift of 8.92 Kips on the forward sockets.

ITEM 13d

$W_4 = 190$

$W_3 = 31$

$W_5 = 236$

$$L_2 = \frac{43.4\ (190) + 903.65 + 17\ (236)}{29.15}$$

$$L_2 = \frac{8246 + 903.65 + 4012}{29.15}$$

$$L_2 = \frac{13161.65}{29.15} = 451.31$$

Beam Load = 451.31 - 31 = 420.31

W_{CW} = 451 - 31 - 190 - 190 = 40.31

This solution is satisfactory because the beam load limit on the Morgan Crane is 448 Kips.

ITEM 13e

$W_4 = 110$

$W_3 = 31$

$W_5 = 236$

$$L_2 = \frac{43.4\ (110) + 903.65 + 17\ (236)}{29.15}$$

$$L_2 = \frac{4774 + 903.65 + 4012}{29.15}$$

$$L_2 = \frac{9689.65}{29.15} = 332.40$$

Beam Load = 332.40 - 31 = 301.40 ~ (Lift is satisfactory)

W_{CW} = 332.40 - 31 - 110 - 236 = -44.6

This item requires a lift of 44.6 Kips on the forward lifting sockets.

ITEM 15

$W_4 = 57$

$W_3 = 31$

X_4 = 75.66 - 39.48 - 2.6 = 33.58

$$L_2 = \frac{33.58\ (57) + 903.65}{29.15}$$

$$L_2 = \frac{1914.06 + 903.65}{29.15} = 96.7$$

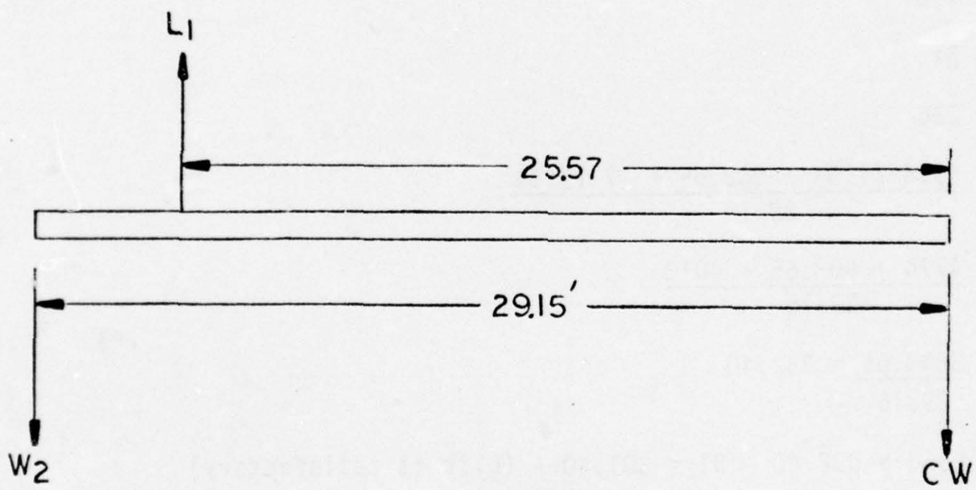
Beam Load = 96.7 - 31 = 65.7 - (Lift is satisfactory)

W_{CW} = 96.7 - 31 - 57 = 8.7

2. LCM-8 LIFTING BEAM w/COUNTERWEIGHTS

ALLIANCE ARRANGEMENT

Sketch B-3



$W_2 = L_2$ Required Morgan Lift

L_1 = Required Alliance Lift

CW = Additional Alliance Counterweight due to load frame (Add to Morgan Counterweight to obtain total).

$$L_1 = \frac{29.15\ L_2}{25.57}$$

$CW = L_1 - W_2$

ITEM 1a

$$L_1 = \frac{29.15\ (235)}{25.57} = 267.9 \text{ - (Lift is satisfactory)}$$

$$CW = 267.9 - 235 = 32.9$$

ITEMS 1b and 1c

$$L_1 = \frac{29.15\ (242.4)}{25.57} = 276.3 \text{ - (Lift is satisfactory)}$$

$$CW = 276.3 - 242.4 = 33.9$$

ITEM 1d

$$L_1 = \frac{29.15\ (245.4)}{25.57} = 279.8 \text{ - (Lift is satisfactory)}$$

$$CW = 279.8 - 245.4 = 34.4$$

ITEM 2a

$$L_1 = \frac{29.15\ (303.5)}{25.57} = 346.0 \text{ - (Lift is satisfactory)}$$

$$CW = 346 - 303.5 = 42.49$$

ITEMS 2b and 2c

$$L_1 = \frac{29.15\ (310.9)}{25.57} = 354.4 \text{ - (Lift is satisfactory)}$$

$$CW = 354.4 - 310.9 = 43.5$$

ITEMS 2d and 2e

$$L_1 = \frac{29.15\ (313.9)}{25.57} = 357.8 \text{ - (Lift is satisfactory)}$$

$$CW = 357.8 - 313.9 = 43.9$$

ITEM 3a

$$L_1 = \frac{29.15\ (147.94)}{25.57} = 168.6 \text{ - (Lift is satisfactory)}$$

$$CW = 168.6 - 147.94 = 20.6$$

ITEM 3b

$$L_1 = \frac{29.15\ (162.31)}{25.57} = 184.96 \text{ - (Lift is satisfactory)}$$

$$CW = 184.96 - 162.31 = 22.6$$

ITEM 3c

$$L_1 = \frac{152.73\ (29.15)}{25.57} = 174.04 \text{ - (Lift is satisfactory)}$$

$$CW = 174.04 - 152.73 = 21.31$$

ITEM 4

$$L_1 = \frac{191\ (29.15)}{25.57} = 217.74 \text{ - (Lift is satisfactory)}$$

$$CW = 217.74 - 191 = 26.74$$

ITEM 5a

$$L_1 = \frac{29.15\ (37.2)}{25.57} = 42.4 \text{ - (Lift is satisfactory)}$$

$$CW = 42.4 - 37.2 = 5.2$$

ITEM 5b

$$L_1 = \frac{29.15\ (49.7)}{25.57} = 56.7 \text{ - (Lift is satisfactory)}$$

$$CW = 56.7 - 49.7 = 7.0$$

ITEM 6

$$L_1 = \frac{29.15\ (230.43)}{25.57} = 262.69 \text{ - (Lift is satisfactory)}$$

$$CW = 262.69 - 230.43 = 32.26$$

ITEM 7

$$L_1 = \frac{29.15\ (273.2)}{25.57} = 311.45 \text{ - (Lift is satisfactory)}$$

$$CW = 311.45 - 273.2 = 38.25$$

ITEM 8a

$$L_1 = \frac{29.15\ (314.4)}{25.57} = 358.4 \text{ - (Lift is satisfactory)}$$

$$CW = 358.4 - 314.4 = 44.01$$

ITEM 8b

$$L_1 = \frac{29.15\ (315.52)}{25.57} = 359.7 \text{ - (Lift is satisfactory)}$$

$$CW = 359.7 - 315.52 = 44.2$$

ITEM 9

$$L_1 = \frac{29.15\ (87)}{25.57} = 99.18 \text{ - (Lift is satisfactory)}$$

$$CW = 99.2 - 87 = 12.2$$

ITEM 10a

$$L_1 = \frac{29.15\ (146)}{25.57} = 166.4 \text{ - (Lift is satisfactory)}$$

$$CW = 166.4 - 146 = 20.4$$

ITEM 10b

$$L_1 = \frac{29.15\ (165)}{25.57} = 188.1 \text{ - (Lift is satisfactory)}$$

$$CW = 188.1 - 165 = 23.1$$

ITEM 11a

$$L_1 = \frac{29.15\ (142)}{25.57} = 161.9 \text{ - (Lift is satisfactory)}$$

$$CW = 161.9 - 142 = 19.9$$

ITEM 11b

$$L_1 = \frac{29.15\ (287.3)}{25.57} = 327.5 \text{ - (Lift is satisfactory)}$$

$$CW = 327.5 - 287.3 = 40.2$$

ITEM 11c

$$L_1 = \frac{29.15\ (355.7)}{25.57} = 405.5 \text{ - (Lift is satisfactory)}$$

$$CW = 405.5 - 355.7 = 49.8$$

ITEM 11d

$$L_1 = \frac{29.15\ (262.0)}{25.57} = 298.7 \text{ - (Lift is satisfactory)}$$

$$CW = 298.7 - 262 = 36.7$$

ITEM 11e

$$L_1 = \frac{29.15\ (236.7)}{25.57} = 269.8 \text{ - (Lift is satisfactory)}$$

$$CW = 269.8 - 236.7 = 33.1$$

ITEM 12a

$$L_1 = \frac{29.15\ (221)}{25.57} = 251.9$$ - (Lift is satisfactory)

CW = 251.9 - 221 = 30.9

ITEM 12b

$$L_1 = \frac{29.15\ (332.7)}{25.57} = 379.3$$ - (Lift is satisfactory)

CW = 379.3 - 332.7 = 46.6

ITEM 12c

$$L_1 = \frac{29.15\ (411.7)}{25.57} = 469.3$$ - (Lift is satisfactory)

CW = 469.3 - 411.7 = 57.6

ITEM 12d

$$L_1 = \frac{29.15\ (288.8)}{25.57} = 329.2$$ - (Lift is satisfactory)

CW = 329.2 - 288.8 = 40.4

ITEM 13a

$$L_1 = \frac{29.15\ (267)}{25.57} = 304.4$$ - (Lift is satisfactory)

CW = 304.4 - 267 = 37.4

ITEM 13b

$$L_1 = \frac{29.15\ (384)}{25.57} = 437.8$$ - (Lift is satisfactory)

CW = 437.8 - 384 = 53.8

ITEM 13c

$$L_1 = \frac{29.15\ (441.1)}{25.57} = 502.9$$ - (Lift is not satisfactory)

$$CW = 502.9 - 441.1 = 61.8$$

ITEM 13d

$$L_1 = \frac{29.15\ (451.3)}{25.57} = 514.5$$ - (Lift is not satisfactory)

$$CW = 514.5 - 451.3 = 63.2$$

ITEM 13e

$$L_1 = \frac{29.15\ (332.4)}{25.57} = 378.9$$ - (Lift is satisfactory)

$$CW = 378.9 - 332.4 = 46.5$$

ITEM 14

$$L_1 = \frac{29.15\ (331)}{25.57} = 377.3$$ - (Lift is satisfactory)

$$CW = 377.3 - 331 = 46.3$$

ITEM 15

$$L_1 = \frac{29.15\ (96.7)}{25.57} = 110.2$$ - (Lift is satisfactory)

$$CW = 110.2 - 96.7 = 13.5$$

ITEM 16

$$L_1 = \frac{29.15\ (76)}{25.57} = 86.6$$ - (Lift is satisfactory)

$$CW = 86.6 - 76 = 10.6$$

ITEM 17

$$L_1 = \frac{29.15\ (228)}{25.57} = 259.9 \text{ - (Lift is satisfactory)}$$

$$CW = 259.9 - 228 = 31.9$$

APPENDIX "C"

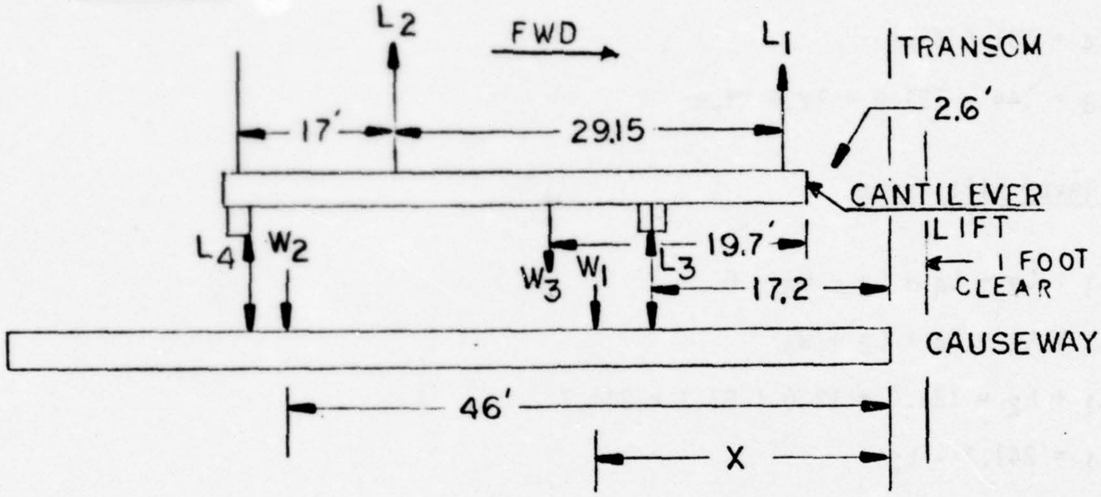
CALCULATIONS FOR CANTILEVER LIFT FRAME

WITH MOVEABLE LIFT POINTS

1. ITEM 1e - 3 x 15 PONTOON CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Sketch C-1



W_2 = 144 Kips - Weight of Causeway Component

L_1 = Load on Forward Lifting Sockets

L_2 = Load on Aft Lifting Sockets

W_3 = 97.7 Kips - Weight of Cantilever Lift Frame

L_3 = Forward Lift on Causeway

L_4 = Aft Lift on Causeway

Calculations

Causeway

$$\Sigma V: \quad L_3 + L_4 - W_2 = 0$$

$$L_3 = W_2 - L_4$$

$$L_3 = 144 - L_4$$

$$\Sigma M: \quad 17.2\, L_3 + 48.75\, L_4 - 46\, W_2 = 0$$

$17.2\ (144 - L_4) + 48.75\ L_4 - 46\ (144) = 0$

$2476.8 - 17.2\ L_4 + 48.75\ L_4 - 6624 = 0$

$48.75\ L_4 - 17.2\ L_4 = 6624 - 2476.8$

$31.55\ L_4 = 4147.2$

$L_4 = 131.4$ Kips

$L_3 = 144 - 131.4 = 12.6$ Kips

<u>Cantilever Lift Frame</u>

ΣV: $L_1 + L_2 - L_4 - L_3 - W_3 = 0$

$L_1 + L_2 = L_4 + L_3 + W_3$

$L_1 + L_2 = 131.4 + 12.6 + 97.7 = 241.7$

$L_1 = 241.7 - L_2$

ΣM: $29.15\ L_2 - 19.7\ W_3 - 46.15\ L_4 - 14.6\ L_3 = 0$

$29.15\ L_2 - 19.7\ (97.7) - 46.15\ (131.4) - 14.6\ (12.6) = 0$

$29.15\ L_2 - 1924.69 - 6064.11 - 183.96 = 0$

$29.15\ L_2 = 1924.69 + 6064.11 + 183.96$

$29.15\ L_2 = 8172.76$

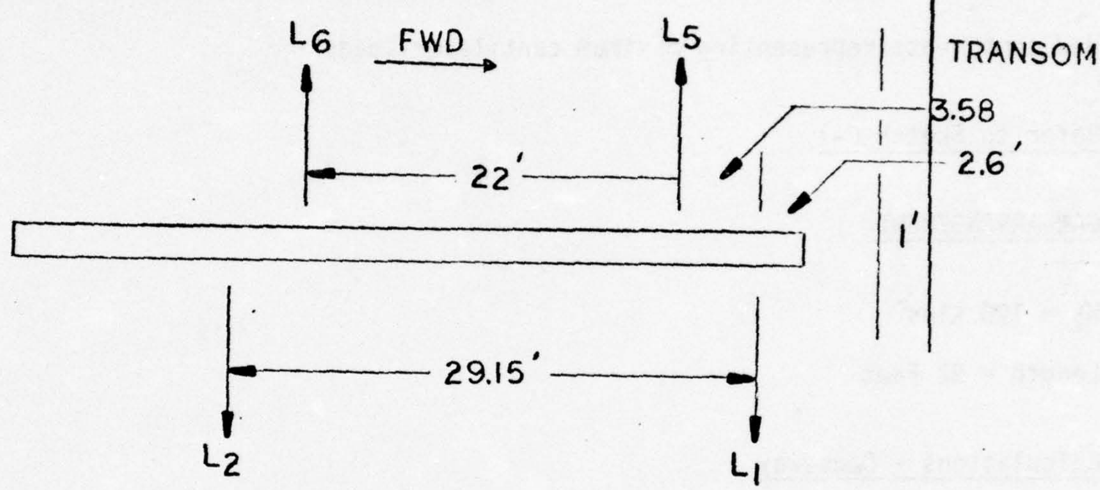
$L_2 = 280.4$ Kips

$L_1 = 241.7 - 280.4 = -38.7$ Kips

The lift is possible with the Morgan Crane with the weight of the load frame acting as a counterweight on the forward sockets of the cantilever lift frame. No counterweight is required on the causeway component.

ALLIANCE ARRANGEMENT

Sketch C-2



ΣV: $L_1 + L_2 - L_5 - L_6 = 0$

$L_5 + L_6 = L_1 + L_2 = 280.4 - 38.7 = 241.7$

$L_5 = 241.7 - L_6$

ΣM: $3.58\ L_5 + 25.58\ L_6 - 29.15\ L_2 = 0$

$3.58\ (241.7 - L_6) + 25.58\ L_6 - 29.15\ (280.4) = 0$

$865.28 - 3.58\ L_6 + 25.58\ L_6 - 8173.66 = 0$

$25.58\ L_6 - 3.58\ L_6 = 8173.66 - 865.28$

$22\ L_6 = 7308.38$

$L_6 = 332.2$ Kips

$L_5 = 241.7 - 332.2 = -90.5$ Kips

The lift is possible with the Alliance Crane without counterweights on the causeway component. A counterweight of 90.5 Kips or 18.5 Kips in addition to the load frame is required on the forward lifting sockets.

2. ITEMS 2d and 2e - 4 x 15 PONTOON CAUSEWAY WITH 6 SPUDWELLS

The following calculations are addressed to some of the heaviest of unloaded components representing maximum cantilever load.

Refer to Sketch C-1

MORGAN ARRANGEMENT

W_2 = 190 Kips

Length = 92 Feet

Calculations - Causeway

$\Sigma V: \quad L_4 + L_3 = W_2$

$L_4 = W_2 - L_3 = 190 - L_3$

$\Sigma M: \quad 48.75\ L_4 - 46\ W_2 + 17.2\ L_3 = 0$

$48.75\ (190 - L_3) - 46\ (190) + 17.2\ L_3 = 0$

$9262.5 - 48.75\ L_3 - 8740 + 17.2\ L_3 = 0$

$48.75\ L_3 - 17.2\ L_3 = 9262.5 - 8740$

$31.55\ L_3 = 522.5$

$L_3 = 16.6$

$L_4 = 190 - 16.6 = 173.4$

Cantilever Lift Frame

$\Sigma V: \quad L_1 + L_2 - L_4 - L_3 - W_3 = 0$

$L_1 + L_2 = L_4 + L_3 + W_3$

$L_1 + L_2 = 173.4 + 16.6 + 97.7$

$L_1 + L_2 = 287.7$

$L_1 = 287.7 - L_2$

Σ M: $29.15\ L_2 - 46.15\ L_4 - 19.7\ W_3 - 14.6\ L_3$

$29.15\ L_2 = 46.15\ L_4 + 19.7\ W_3 + 14.6\ L_3$

$29.15\ L_2 = 46.15\ (173.4) + 19.7\ (97.7) + 14.6\ (16.6)$

$29.15\ L_2 = 8002.41 + 1924.69 + 242.36$

$29.15\ L_2 = 10169.46$

$L_2 = 348.9$

$L_1 = 287.7 - L_2 = 287.7 - 348.9 = -61.2$

The lift is possible with the Morgan Arrangement. The 61.2 Kips counterweight required on the forward pulleys can be compensated for by the weight of the load frame.

ALLIANCE ARRANGEMENT

Refer to Sketch C-2

Σ V: $L_1 + L_2 - L_5 - L_6 = 0$

$L_6 + L_5 = L_1 + L_2 = 348.9 - 61.2 = 287.7$

$L_6 = 287.7 - L_5$

Σ M: $25.58\ L_6 + 3.58\ L_5 - 29.15\ L_2 = 0$

$25.58\ (287.7 - L_5) + 3.58\ L_5 - 29.15\ (348.9) = 0$

$25.58\ (287.7) - 25.58\ L_5 + 3.58\ L_5 - 29.15\ (348.9) = 0$

$7359.36 - 25.58\ L_5 + 3.58\ L_5 - 10170.4 = 0$

$25.58\ L_5 - 3.58\ L_5 = 7359.36 - 10170.4$

$22\ L_5 = -2811.04$

$L_5 = -127.8$

$L_6 = 287.7 - (-127.8) = 415.5$

The lift is possible with the Alliance Arrangement, but additional

counterweight over and above the 72 Kips contributed by the load frame would have to be attached to the forward lifting sockets to keep the lighter frame from rotating.

3. ITEM 4 - AMMI PONTOON CAUSEWAY

MORGAN ARRANGEMENT

Refer to Sketch C-1

W_2 = 110 Kips

Length of Component = 90 Feet

Calculations - Causeway

$\Sigma V: \quad L_3 + L_4 - W_2 = 0$

$L_3 = 110 - L_4$

$\Sigma M: \quad 17.2\, L_3 + 48.75\, L_4 - 45\, W_2 = 0$

$17.2\,(110 - L_4) + 48.75\, L_4 - 45\,(110) = 0$

$1892 - 17.2\, L_4 + 48.75\, L_4 - 4950 = 0$

$48.75\, L_4 - 17.2\, L_4 = 4950 - 1892$

$31.55\, L_4 = 3058$

$L_4 = 96.9$ Kips

$L_3 = 110 - 96.9 = 13.1$ Kips

Cantilever Lift Frame

$\Sigma V: \quad L_1 + L_2 - L_3 - W_3 - L_4 = 0$

$L_1 + L_2 = L_3 + W_3 + L_4$

$L_1 + L_2 = 13.1 + 97.7 + 96.9 = 207.7$

$L_1 = 207.7 - L_2$

M: $29.15\ L_2 - 14.6\ L_3 - 19.7\ W_3 - 46.15\ L_4 = 0$

$29.15\ L_2 - 14.6\ (13.1) - 19.7\ (97.7) - 46.15\ (96.9) = 0$

$29.15\ L_2 - 191.26 - 1924.69 - 4471.93 = 0$

$29.15\ L_2 = 191.26 + 1924.69 + 4471.93$

$29.15\ L_2 = 6587.88$

$L_2 = 226.0$ Kips

$L_1 = 207.7 - 226 = -18.3$

The lift is possible with the Morgan Crane. The 18.3 Kips required as counterweight on the forward lifting sockets is satisfied with the weight of the crane load frame.

ALLIANCE ARRANGEMENT

Refer to Sketch C-2

V: $L_5 + L_5 - L_1 - L_2 = 0$

$L_5 + L_6 = L_1 + L_2 = 226 - 18.3 = 207.7$

$L_5 = 207.7 - L_6$

M: $3.58\ L_5 + 25.58\ L_6 - 29.15\ L_2 = 0$

$3.58\ (207.7 - L_6) + 25.58\ L_6 - 29.15\ (226) = 0$

$743.57 - 3.58\ L_6 + 25.58\ L_6 - 6587.9 = 0$

$25.58\ L_6 - 3.58\ L_6 = 6587.9 - 743.57$

$22\ L_6 = 5844.33$

$L_6 = 265.7$

$L_5 = 207.7 - 265.7 = -58$ Kips

The lift is possible with the Alliance Crane with a counterweight of 58 Kips on the forward lifting sockets. This can be satisfied with the weight of the load frame.

4. ITEM 6 - WATER-JET PROPELLED CAUSEWAY

MORGAN ARRANGEMENT

Refer to Sketch C-1

W_2 = 205.3 Kips

CG = 37 Ft. From Forward Extremity

Length = 90 Feet

Calculations - Causeway

ΣV: $L_3 - W_2 + L_4 = 0$

$L_3 = W_2 - L_4$

$L_3 = 205.3 - L_4$

ΣM: $17.2\ L_3 - 37\ W_2 + 48.75\ L_4 = 0$

$17.2\ (205.3 - L_4) - 37\ (205.3) + 48.75\ L_4 = 0$

$3531.16 - 17.2\ L_4 - 7596.1 + 48.75\ L_4 = 0$

$48.75\ L_4 - 17.2\ L_4 = 7596.1 - 3531.16$

$31.55\ L_4 = 4064.94$

$L_4 = 128.8$

$L_3 = 205.3 - 128.8 = 76.5$

Cantilever Lift Frame

ΣV: $L_1 + L_2 - L_3 - W_3 - L_4 = 0$

$L_1 + L_2 = L_3 + W_3 + L_4$

$L_1 + L_2 = 303$

$L_1 = 303 - L_2$

$$M: \quad 29.15\ L_2 - 19.7\ W_3 - 14.6\ L_3 - 46.15\ L_4 = 0$$

$$29.15\ L_2 - 19.7\ (97.7) - 14.6\ (76.3) - 46.15\ (128.8) = 0$$

$$29.15\ L_2 - 1924.69 - 1113.98 - 5944.12 = 0$$

$$29.15\ L_2 = 1924.69 + 1113.98 + 5944.12$$

$$29.15\ L_2 = 8982.79$$

$$L_2 = 308.1$$

$$L_1 = 303 - 308.1 = -5.1$$

The lift is possible with the Morgan Crane and the small counterweight on the forward sockets can be easily satisfied by the weight of the load frame.

ALLIANCE ARRANGEMENT

See Sketch C-2

$$V: \quad L_5 + L_6 - L_1 - L_2 = 0$$

$$L_5 + L_6 = L_1 + L_2 = 308.1 - 5.1 = 303$$

$$L_5 = 303 - L_6$$

$$M: \quad 3.58\ L_5 + 25.58\ L_6 - 29.15\ L_2 = 0$$

$$3.58\ (303 - L_6) + 25.58\ L_6 - 29.15\ (308.1) = 0$$

$$1084.74 - 3.58\ L_6 + 25.58\ L_6 - 8981.11 = 0$$

$$25.58\ L_6 - 3.58\ L_6 = 8981.11 - 1084.74$$

$$22\ L_6 = 7986.37$$

$$L_6 = 358.9$$

$$L_5 = 303 - 358.9 = -55.9$$

The lift is possible with the Alliance Crane and the counterweight required on the forward sockets of 55.9 Kips can be satisfied by the weight of the load frame.

5. ITEM 7 - 3 x 14 PONTOON WARPING TUG

MORGAN ARRANGEMENT

See Sketch C-1

W_2 = 194 Kips

CG = 39' From Forward Extremity

Length = 90 Feet

Calculations - Causeway

$$\Sigma V: \quad L_3 + L_4 - W_2 = 0$$

$$L_3 = W_2 - L_4$$

$$L_3 = 194 - L_4$$

$$\Sigma M: \quad 17.2\, L_3 - 39\, W_2 + 48.75\, L_4 = 0$$

$$17.2\,(194 - L_4) - 39\,(194) + 48.75\, L_4 = 0$$

$$3336.8 - 17.2\, L_4 - 7566 + 48.75\, L_4 = 0$$

$$48.75\, L_4 - 17.2\, L_4 = 7566 - 3336.8$$

$$31.55\, L_4 = 4229.2$$

$$L_4 = 134.05$$

$$L_3 = 194 - 134.05 = 59.9$$

Cantilever Lift Frame

$$\Sigma V: \quad L_1 + L_2 - L_3 - W_3 - L_4 = 0$$

$$L_1 + L_2 = L_3 + W_3 + L_4$$

$$L_1 + L_2 = 59.9 + 97.7 + 134.05$$

$$L_1 + L_2 = 291.65$$

$$L_1 = 291.65 - L_2$$

ΣM: $29.15 L_2 - 19.7 W_3 - 14.6 L_3 - 46.15 L_4 = 0$

$29.15 L_2 - 19.7 (97.7) - 14.6 (59.9) - 46.15 (134.05) = 0$

$29.15 L_2 - 1924.69 - 874.54 - 6186.4 = 0$

$29.15 L_2 = 1924.69 + 874.54 + 6186.4$

$29.15 L_2 = 8985.63$

$L_2 = 308.25$

$L_1 = 291.65 - 308.25 = -16.6$

The Morgan Crane is satisfactory. The counterweight of 16.6 Kips required on the forward sockets can be satisfied by the load frame weight.

ALLIANCE ARRANGEMENT

See Sketch C-2

ΣV: $L_5 + L_6 - L_1 - L_2 = 0$

$L_5 + L_6 = L_1 + L_2 = 308.25 - 16.6 = 291.65$

$L_5 = 291.65 - L_6$

ΣM: $3.58 L_5 + 25.58 L_6 - 29.15 L_2 = 0$

$3.58 (291.65 - L_6) + 25.58 L_6 - 29.15 (308.25) = 0$

$1044.1 - 3.58 L_6 + 25.58 L_6 - 8985.48 = 0$

$25.58 L_6 - 3.58 L_6 = 8985.48 - 1044.1$

$22 L_6 = 7941.38$

$L_6 = 361.0$

$L_5 = 291.65 - 361 = -69.35$

The Alliance Crane is satisfactory. The counterweight of 69.3 Kips on the forward sockets can be satisfied by the weight of the load frame.

6. ITEM 8b - SIDE LOADABLE WARPING TUG WITH WATER JET PROPULSION

MORGAN ARRANGEMENT

Refer to Sketch C-1

W_2 = 230 Kips

CG = 38.7 Feet From Forward Extremity

Length = 91.7 Feet

Calculations - Causeway

$$\Sigma V: \quad L_3 + L_4 - W_2 = 0$$

$$L_3 = W_2 - L_4$$

$$L_3 = 230 - L_4$$

$$\Sigma M: \quad 17.2\, L_3 + 48.75\, L_4 - 38.7\, W_2 = 0$$

$$17.2\,(230 - L_4) + 48.75\, L_4 - 38.7\,(230) = 0$$

$$3956 - 17.2\, L_4 + 48.75\, L_4 - 8901 = 0$$

$$48.75\, L_4 - 17.2\, L_4 = 8901 - 3956$$

$$31.55\, L_4 = 4945$$

$$L_4 = 156.7$$

$$L_3 = 230 - 156.7 = 73.3$$

Cantilever Lift Frame

$$\Sigma V: \quad L_1 + L_2 - L_3 - W_3 - L_4 = 0$$

$$L_1 + L_2 = L_3 + W_3 + L_4$$

$$L_1 + L_2 = 73.3 + 156.7 + 97.7$$

$$L_1 + L_2 = 327.7$$

$$L_2 = 327.7 - L_1$$

ΣM: $29.15\ L_2 - 19.7\ W_3 - 14.6\ L_3 - 46.15\ L_4 = 0$

$29.15\ (327.7 - L_1) - 19.7\ (97.7) - 14.6\ (73.3) - 46.15\ (156.7) = 0$

$9552.45 - 29.15\ L_1 - 1924.69 - 1070.18 - 7231.7 = 0$

$29.15\ L_1 = 9552.45 - 1924.69 - 1070.18 - 7231.7$

$29.15\ L_1 = -674.12$

$L_1 = -23.1$

$L_2 = 327.7 - (-23.1) = 350.8$

The lift is possible with the Morgan Crane requiring a counterweight of 23.1 Kips on the forward sockets. This can be satisfied by the weight of the load frame.

ALLIANCE ARRANGEMENT

Refer to Sketch C-2

ΣV: $L_5 + L_6 - L_1 - L_2 = 0$

$L_5 + L_6 = L_1 + L_2 = 327.7$

$L_5 = 327.7 - L_6$

ΣM: $3.58\ L_5 + 25.58\ L_6 - 29.15\ L_2 = 0$

$3.58\ (327.7 - L_6) + 25.58\ L_6 - 29.15\ (350.8) = 0$

$1173.7 - 3.58\ L_6 + 25.58\ L_6 - 10225.82 = 0$

$25.58\ L_6 - 3.58\ L_6 = 10225.82 - 1173.7$

$22\ L_6 = 9052.12$

$L_6 = 411.5$

$L_5 = 327.7 - 411.5$

$L_5 = -83.8$

The lift is possible with the Alliance Arrangement but an additional

counterweight of 11.8 Kips will have to be added to the forward lifting sockets or to the forward end of the cantilever lift frame.

7. ITEM 11b - P & H 9125 TRUCK CRANE WITH 60 FOOT BOOM

MORGAN ARRANGEMENT

Refer to Sketch C-1

W_2 = 144 Kips Weight of Causeway Section

W_1 = 111 Kips Weight of Bare Crane

Let X = 17.2 Ft. Position of CG

Length = 92 Ft.

Calculations - Causeway

$\Sigma V: \quad L_3 + L_4 - W_1 - W_2 = 0$

$L_3 + L_4 = W_1 + W_2$

$L_3 + L_4 = 255$

$L_3 = 255 - L_4$

$\Sigma M: \quad 17.2\ L_3 + 48.75\ L_4 - 17.2\ W_1 - 46\ W_2 = 0$

$17.2\ (255 - L_4) + 48.75\ L_4 - 17.2\ (111) - 46\ (144) = 0$

$17.2\ (255) - 17.2\ L_4 + 48.75\ L_4 - 17.2\ (111) - 46\ (144) = 0$

$4386 - 17.2\ L_4 + 48.75\ L_4 - 1909.2 - 6624 = 0$

$48.75\ L_4 - 17.2\ L_4 = 6624 + 1909.2 - 4386$

$31.55\ L_4 = 4147.2$

$L_4 = 131.45$

$L_3 = 255 - 131.45 = 123.55$

Cantilever Lift Frame

Σ V: $L_1 + L_2 - L_3 - W_3 - L_4 = 0$

$L_1 + L_2 = L_3 + W_3 + L_4$

$L_1 + L_2 = 123.55 + 97.7 + 131.45$

$L_1 + L_2 = 352.7$

$L_1 = 352.7 - L_2$

Σ M: $29.15\ L_2 - 14.6\ L_3 - 19.7\ W_3 - 46.15\ L_4 = 0$

$29.15\ L_2 - 14.6\ (123.5) - 19.7\ (97.7) - 46.15\ (131.45) = 0$

$29.15\ L_2 - 1803.1 - 1924.69 - 6066.42 = 0$

$29.15\ L_2 = 6066.42 + 1924.69 + 1803.1$

$29.15\ L_2 = 9794.2$

$L_2 = 335.9$

$L_1 = 352.7 - 335.9$

$L_1 = 16.8$

The lift is possible with the crane center of gravity 17.2 feet aft of the forward extremity of causeway section. No counterweights are required on the causeway or the lifting frame.

ALLIANCE ARRANGEMENT

See Sketch C-2

Σ V: $L_5 + L_6 - L_1 - L_2 = 0$

$L_5 + L_6 = L_1 + L_2 = 352.7$

$L_5 = 352.7 - L_6$

Σ M: $3.58\ L_5 + 25.58\ L_6 - 29.15\ L_2 = 0$

$3.58\ (352.7 - L_6) + 25.58\ L_6 - 29.15\ (335.9) = 0$

$1262.67 - 3.58\ L_6 + 25.58\ L_6 - 9791.48 = 0$

$25.58\ L_6 - 3.58\ L_6 = 9791.48 - 1262.67$

$22\ L_6 = 8528.81$

$L_6 = 387.7$

$L_5 = 352.7 - 387.7$

$L_5 = -35$

The lift is possible with the Alliance Arrangement. The counterweight of 35 Kips required on the forward lifting sockets is satisfied by the weight of the load frame.

8. ITEM 12c - P & H 9125 TRUCK CRANE WITH 60 FOOT BOOM ON 4 x 15 CAUSEWAY

MORGAN ARRANGEMENT

Refer to Sketch C-1

Length of Causeway = 92 Feet

W_2 = 190 Kips = Weight of Causeway

W_1 = 190 Kips - Weight of Crane

Let X = 17.2 Ft. Position of CG

Calculations - Causeway

Σ V: $L_3 + L_4 - W_1 - W_2 = 0$

$L_3 + L_4 = W_1 + W_2$

$L_3 + L_4 = 190 + 190 = 380$

$L_3 = 380 - L_4$

Σ M: $17.2\ L_3 + 48.75\ L_4 - 17.2\ W_1 - 46\ W_2 = 0$

$$17.2\ (380 - L_4) + 48.75\ L_4 - 17.2\ (190) - 46\ (190) = 0$$

$$6536 - 17.2\ L_4 + 48.75\ L_4 - 3268 - 8740 = 0$$

$$48.75\ L_4 - 17.2\ L_4 = 8740 + 3268 - 6536 = 0$$

$$31.55\ L_4 = 5472$$

$$L_4 = 173.4$$

$$L_3 = 380 - 173.4$$

$$L_3 = 206.6$$

Cantilever Lift Frame

$$\Sigma V: \quad L_1 + L_2 - L_3 - W_3 - L_4 = 0$$

$$L_1 + L_2 = L_3 + W_3 + L_4$$

$$L_1 + L_2 = 206.6 + 97.7 + 173.4$$

$$L_1 + L_2 = 477.7$$

$$L_1 = 477.7 - L_2$$

$$\Sigma M: \quad 29.15\ L_2 - 14.6\ L_3 - 19.7\ W_3 - 46.15\ L_4 = 0$$

$$29.15\ L_2 - 14.6\ (206.6) - 19.7\ (97.7) - 46.15\ (173.4) = 0$$

$$29.15\ L_2 - 3016.36 - 1924.69 - 8002.41 = 0$$

$$29.15\ L_2 = 3016.36 + 1924.69 + 8002.41$$

$$29.15\ L_2 = 12943.46$$

$$L_2 = 444.0$$

$$L_1 = 477.7 - 444 = 33.7$$

The lift is possible with the Morgan Crane with the crane center of gravity 17.2 feet aft of the forward causeway extremity. No counterweight is required.

ALLIANCE ARRANGEMENT

Refer to Sketch C-2

Σ V: $L_5 + L_6 - L_1 - L_2 = 0$

$L_5 + L_6 = L_1 + L_2$

$L_5 + L_6 = 477.7$

$L_5 + 477.7 - L_6$

Σ M: $3.58\ L_5 + 25.58\ L_6 - 29.15\ L_2 = 0$

$3.58\ (477.7 - L_6) + 25.58\ L_6 - 29.15\ (444) = 0$

$1710.16 - 3.58\ L_6 + 25.58\ L_6 - 12942.6 = 0$

$25.58\ L_6 - 3.58\ L_6 = 12942.6 - 1710.6$

$22\ L_6 = 11232$

$L_6 = 510.5$

$L_5 = 477.7 - 510.5 = -32.8$

The lift is not possible with the Alliance Crane because 510 Kips exceeds the maximum lift allowed on the aft pulleys.

The lift will be recalculated using a value of 15.0 for the crane Center of Gravity.

Refer to Sketch C-1

Σ V: $L_3 = 380 - L_4$

Σ M: $17.2\ (380 - L_4) + 48.75\ L_4 - 15\ (190) - 46\ (190)$

$6536 - 17.2\ L_4 + 48.75\ L_4 - 2850 - 8740 = 0$

$48.75\ L_4 - 17.2\ L_4 = 8740 + 2850 - 6536$

$31.55\ L_4 = 5054$

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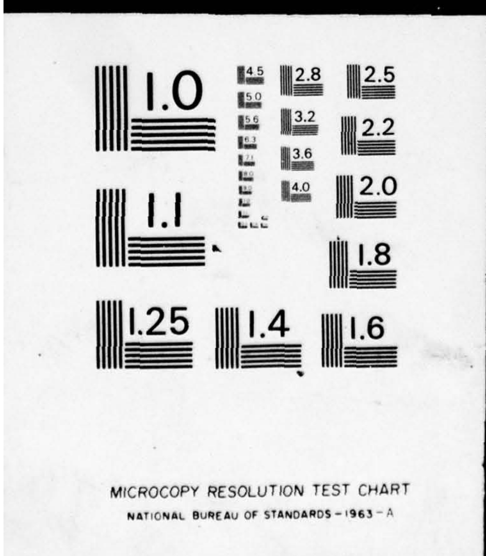
1.0
4.5
5.0
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

$$L_4 = 160.19$$

$$L_3 = 380 - 160.19$$

$$L_3 = 219.8$$

$$L_1 + L_2 - L_3 - W_3 - L_4 = 0$$

$$L_1 + L_2 = L_3 + W_3 + L_4$$

$$L_1 + L_2 = 219.8 + 97.7 + 160.2 = 477.7$$

$$L_1 = 477.7 - L_2$$

$$29.15\ L_2 - 14.6\ (219.8) - 19.7\ (97.7) - 46.15\ (160.2) = 0$$

$$29.15\ L_2 - 3209.08 - 1924.69 - 7393.23 = 0$$

$$29.15\ L_2 = 3209.08 + 1924.69 + 7393.23$$

$$29.15\ L_2 = 12527.0$$

$$L_2 = 429.7$$

$$L_1 = 477.7 - 429.7 = 48$$

$$L_5 = 477.7 - L_6$$

$$3.58\ L_5 + 25.58\ L_6 - 29.15\ L_2 = 0$$

$$22\ L_6 = 12525.7 - 1710.6$$

$$22\ L_6 = 10815.1$$

$$L_6 = 491.6$$

$$L_5 = 477.7 - 491.6 = -13.9$$

The lift is possible with the Alliance Crane when the crane center of gravity is 15 feet from the forward end of the causeway. The counterweight of 13.9 Kips required on the forward pulleys can be satisfied by the weight of the load frame.

9. ITEM 13d - P & H TRUCK CRANE ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Refer to Sketch C-1

Length of Causeway = 92 Feet

W_1 = 236 Kips - Weight of Crane

W_2 = 190 Kips - Weight of Causeway Component

Calculations - Causeway

$\Sigma V: \quad L_3 + L_4 - W_1 - W_2 = 0$

$L_3 + L_4 = W_1 + W_2 = 236 + 190 = 426$

$L_3 = 426 - L_4$

ΣM: Let X = 20'

$20\ W_1 + 46\ W_2 - 48.75\ L_4 - 17.2\ L_3 = 0$

$20\ (236) + 46\ (190) - 48.75\ L_4 - 17.2\ (426 - L_4) = 0$

$4720 + 8740 - 48.75\ L_4 - 7327.2 + 17.2\ L_4 = 0$

$48.75\ L_4 - 17.2\ L_4 = 4720 + 8740 - 7327.2$

$31.55\ L_4 = 6132.8$

$L_4 = 194.4$

$L_3 = 426 - 194.4 = 231.6$

Cantilever Lift Frame

$\Sigma V: \quad L_1 + L_2 - L_4 - L_3 - 97.7 = 0$

$L_1 + L_2 - 194.4 - 231.6 - 97.7 = 0$

$L_1 + L_2 = 194.4 + 231.6 + 97.7$

$L_1 + L_2 = 523.7$

$L_1 = 523.7 - L_2$

ΣM: $29.15\ L_2 - 46.15\ L_4 - 19.7\ (97.7) - 14.6\ L_3 = 0$

$29.15\ L_2 - 46.15\ (194.4) - 19.7\ (97.7) - 14.6\ (231.6) = 0$

$29.15\ L_2 = 8971.56 + 1924.69 + 3381.36$

$29.15\ L_2 = 14227.61$

$L_2 = 489.8$

$L_1 = 523.7 - 489.8 = 33.9$

The lift is possible with the Morgan Crane without counterweights.

ALLIANCE ARRANGEMENT

Refer to Sketch C-2

ΣV: $L_1 + L_2 - L_6 - L_5 = 0$

$L_6 + L_5 = 33.9 + 489.8 = 523.7$

$L_5 = 523.7 - L_6$

ΣM: $22\ L_6 + 3.58\ L_1 - 25.58\ L_2 = 0$

$22\ L_6 + 3.58\ (33.9) - 25.58\ (489.8) = 0$

$22\ L_6 = 25.58\ (489.8) - 3.58\ (33.9)$

$22\ L_6 = 12529.08 - 121.4 = 12407.17$

$L_6 = 564$

$L_5 = 523.7 - 564 = 40.3$

The lift is impossible with the crane center of gravity positioned 20 feet aft of the forward end of the causeway.

The lift with the Alliance Crane will be calculated with the crane center of gravity at 17 feet.

Referring to Sketch C-1, the values of L_3 and L_4 will be recalculated with W_1 at 17 feet from the end of the causeway.

$\lessgtr$ M: Let X = 17'

$17 W_1 + 46 W_2 - 48.75 L_4 - 17.2 L_3 = 0$

$17 (236) + 46 (190) - 48.75 L_4 - 17.2 (426 - L_4) = 0$

$4012 + 8740 - 48.75 L_4 - 7327.2 + 17.2 L_4 = 0$

$48.75 L_4 - 17.2 L_4 = 4012 + 8740 - 7327.2$

$31.55 L_4 = 5424.8$

$L_4 = 171.94$

$L_3 = 426 - 171.94 = 254.06$

$\lessgtr$ V: $L_1 + L_2 - L_4 - L_3 - 97.7 = 0$

$L_1 + L_2 - 171.94 - 254.06 - 97.7 = 0$

$L_1 + L_2 = 171.94 + 254.06 + 97.7$

$L_1 + L_2 = 523.7$

$L_1 = 523.7 - L_2$

$\lessgtr$ M: $29.15 L_2 - 46.15 L_4 - 19.7 (97.7) - 14.6 L_3 = 0$

$29.15 L_2 - 46.15 (171.94) - 19.7 (97.7) - 14.6 (254.06) = 0$

$29.15 L_2 = 7935.03 + 1924.69 + 3709.27$

$29.15 L_2 = 13568.99$

$L_2 = 465.48$

$L_1 = 523.7 - 465.48 = 58.22$

$\lessgtr$ V: $L_1 + L_2 - L_6 - L_5 = 0$

$L_6 + L_5 = L_1 + L_2 = 58.22 + 465.48 = 523.7$

$L_5 = 523.7 - L_6$

Σ M: $22\ L_6 + 3.58\ L_1 - 25.58\ L_2 = 0$

$$22\ L_6 + 3.58\ (58.2) - 25.58\ (465.5) = 0$$

$$22\ L_6 + 208.4 - 11907.5 = 0$$

$$22\ L_6 = 11700.1$$

$$L_6 = 532.0$$

$$L_5 = 523.7 - 532 = -8.3$$

If the lift were attempted with the Alliance Arrangement with the P & H Crane center of gravity at the 17 foot position, the crane would be overloaded on the aft pulleys.

10. CALCULATIONS OF CANTILEVER LIFT FRAME DIMENSIONS

The cantilever lift frame shall be box girder construction where the cross section of the new longitudinal members is determined as follows:

$L = \dfrac{s\ b\ h^2}{6\ \ell}$ where:

L = Load in pounds

s = 18000 psi stress

b = Width in inches (assume 12 inches)

h = Height in inches

ℓ = Length in inches

$$h^2 = \frac{6\ L\ \ell}{s\ b} = \frac{6\ (190)\ (17)\ (12)\ (1000)}{18000\ (12)} = 1076 \text{ inches}^2$$

$$h = \sqrt{1076} = 32.8 \text{ inches}$$

Based on the above calculations fore and aft girder dimensions shall be 12" x 36".

Cross members are to be determined by the following formula:

$$L = \frac{2\ s\ b\ h^2}{3\ \ell} \text{ where:}$$

L = Load in pounds

s = Stress of 18000 psi

b = Width of beam in inches (assume 24 inches)

h = Height of beam in inches

ℓ = Length of beam in inches

$$h^2 = \frac{3\ \ell\ L}{2\ s\ b} = \frac{3\ (52)\ (300)\ (12)\ (1000)}{2\ (18000)\ (24)} = 650 \text{ inches}^2$$

$$h = \sqrt{650} = 25.5 \text{ inches}$$

From the above calculations, dimensions of cross members shall be 24" x 30".

Based on these cross sectional areas, estimated weight of the cantilever frame is 97.7 Kips, with a center of gravity approximately 19.7 feet from the forward extremity. Cross members will be fitted with moveable lift points as discussed in previous paragraphs.

APPENDIX "D"

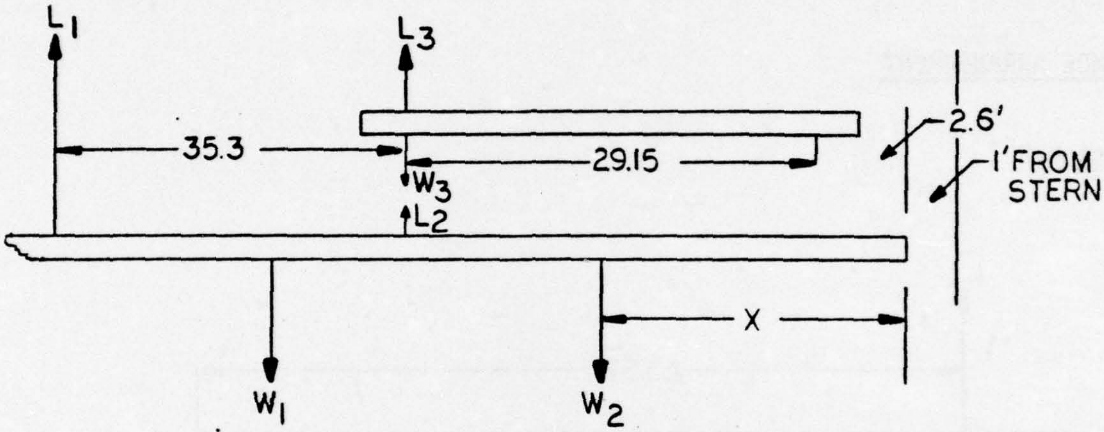
CALCULATIONS FOR USE OF

JIB BOOM ON LIGHTER CRANE

1. ITEM 11c - BUCYRUS ERIE CRANE MK-100 ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Sketch D-1



$X = 11'$

$W_3 = 31$

$W_2 = 111$

$W_1 = 190$

L_2 = LCM-8 Beam Load

L_1 = External Lift

ΣV: $L_1 + L_2 - W_1 - W_2 = 0$

$L_1 + L_2 = W_1 + W_2 = 190 + 111 = 301$

$L_2 + 301 - L_1$

ΣM: $67.05\ L_1 + 31.75\ L_2 - 46\ W_1 - 11\ W_2 = 0$

$67.05\ L_1 + 31.75\ (301 - L_1) - 46\ (190) - 11\ (111) = 0$

$67.05\ L_1 + 9556.75 - 31.75\ L_1 - 8740 - 1221 = 0$

$67.05\ L_1 - 31.75\ L_1 = 8740 + 1221 - 9556.75$

$35.3\ L_1 = 405$

$L_1 = 11.47$ External Lift

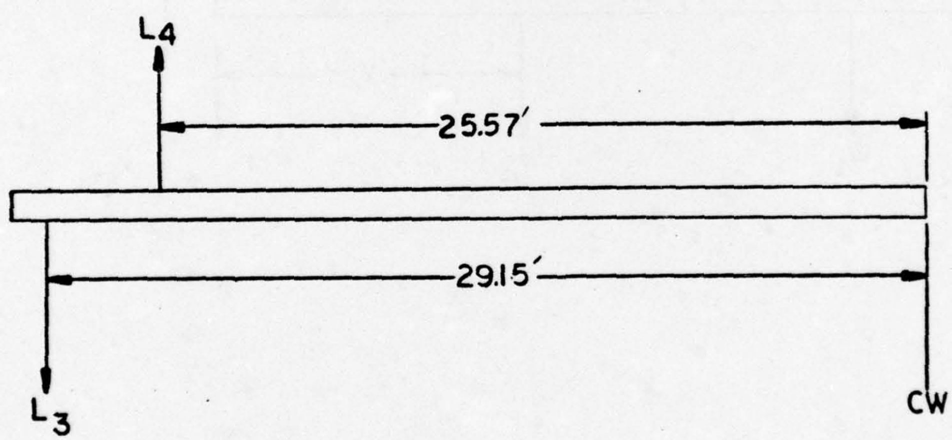
$L_2 = 301 - 11.47 = 289.53$ Beam Load

$L_3 = L_2 + W_3$

$L_3 = 289.53 + 31 = 320.53$ Lift on Aft Sockets is satisfactory

ALLIANCE ARRANGEMENT

Sketch D-2



$L_3 = 320.53$

$L_4 = L_3 + CW$

$L_4 = \dfrac{29.15\ (320.53)}{25.57} = 365.40$ Lift on Aft Pulleys is satisfactory

$CW = L_4 - L_3$

$CW = 365.40 - 320.53 = 44.87$ Counterweight on Forward End of Load Frame

2. ITEM 12c - P & H 9125 TRUCK CRANE ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Refer to Sketch D-1

$X = 15'$

$W_3 = 31$

$W_1 = 190$

$W_2 = 190$

ΣV: $L_1 + L_2 = W_1 + W_2$

$L_1 + L_2 = 190 + 190 = 380$

$L_2 = 380 - L_1$

ΣM: $67.05\ L_1 + 31.75\ L_2 - 46\ W_1 - 15\ W_2 = 0$

$67.05\ L_1 + 31.75\ (380 - L_1) - 46\ (190) - 15\ (190) = 0$

$67.05\ L_1 + 12065 - 31.75\ L_1 - 8740 - 2850 = 0$

$67.05\ L_1 - 31.75\ L_1 = 8740 + 2850 - 12065$

$35.3\ L_1 = -475$

$L_1 = -13.46$ Negative External Lift Required with the Crane Only 15 Feet from the Forward End of the Causeway

$L_2 = 380 - (-13.46) = 393.46$ Beam Load

$L_3 = L_2 + W_3$

$L_3 = 393.46 + 31 = 424.46$ Lift on the Aft Sockets is satisfactory

ALLIANCE ARRANGEMENT

Refer to Sketch D-2

$L_4 = L_3 + CW$

$L_4 = \frac{29.15\ (424.46)}{25.57} = 483.88$ Lift on the Aft Pulleys is satisfactory

$CW = L_4 - L_3 = 483.88 - 424.46 = 59.42$ Counterweight on Forward End of the Load Frame

3. ITEM 13d - P & H 6250 TRUCK CRANE ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Refer to Sketch D-1

$X = 17'$

$W_3 = 31$

$W_1 = 190$

$W_2 = 236$

ΣV: $L_1 + L_2 = W_1 + W_2$

$L_1 + L_2 = 426$

$L_2 = 426 - L_1$

ΣM: $67.05\ L_1 + 31.75\ L_2 - 46\ W_1 - 17\ W_2 = 0$

$67.05\ L_1 + 31.75\ (426 - L_1) - 46\ (190) - 17\ (236) = 0$

$67.05\ L_1 + 13525.5 - 31.75\ L_1 - 8740 - 4012 = 0$

$67.05\ L_1 - 31.75\ L_1 = 8740 + 4012 - 13525.5$

$35.3\ L_1 = -773$

$L_1 = -21.9$ Negative External Lift Required With Crane at the 17 Foot Position.

$L_2 = 426 - L_1 = 426 - (-21.9) = 447.9$ Beam Load

The resultant beam load is approximately the maximum limit.

$L_3 = L_2 + W_3$

$L_3 = 447.9 + 31 = 478.9$ Load on the Aft Lifting Sockets is satisfactory

ALLIANCE ARRANGEMENT

Refer to Sketch D-2

$$L_4 = \frac{29.15\ (478.9)}{25.57} = 545.7$$ Lift Would be Impossible.

$CW = L_4 - L_3 = 545.7 - 478.9 = 66.8$

4. ITEM 11c - BUCYRUS ERIE CRANE MK-100 ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

The following calculations will determine the value of the external lift when the load is placed under the lift beam.

MORGAN ARRANGEMENT

Refer to Sketch D-1

$X = 31.75$

$W_3 = 31$

$W_1 = 190$

$W_2 = 111$

$L_2 = 301 - L_1$

$$\Sigma M: \quad 67.05\ L_1 + 31.75\ (301 - L_1) - 46\ (190) - 31.75\ (111) = 0$$

$$67.05\ L_1 + 9556.75 - 31.75\ L_1 - 8740 - 3524.25 = 0$$

$$67.05\ L_1 - 31.75\ L_1 = 8740 + 3524.25 - 9556.75$$

$$35.3\ L_1 = 2707.5$$

$L_1 = 76.7$ External Lift

$L_2 = 301 - 76.7 = 224.3$ Beam Load

$L_3 = L_2 + W_3$

$L_3 = 255.3$ Load on After Lift Sockets is satisfactory

ALLIANCE ARRANGEMENT

Refer to Sketch D-2

$$L_4 = \frac{29.15\ L_3}{25.57}$$

$L_4 = \frac{29.15\ (255.3)}{25.57} = 291.0$ Lift on Aft Pulleys is satisfactory

$CW = L_4 - L_3 = 291.0 - 255.3 = 35.7$ Counterweight on Forward End of Load Frame

5. ITEM 12c - P & H 9125 TRUCK CRANE ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Refer to Sketch D-1

$X = 31.75$

$W_3 = 31$

$W_2 = 190$

$W_1 = 190$

$L_2 = 380 - L_1$

$\leq M$: $67.05\ L_1 + 31.75\ (380 - L_1) - 46\ (190) - 31.75\ (190) = 0$

$67.05\ L_1 + 12065 - 31.75\ L_1 - 8740 - 6032.5 = 0$

$67.05\,L_1 - 31.75\,L_1 = 8740 + 6032.5 - 12065$

$35.3\,L_1 = 2707.5$

$L_1 = 76.7$ External Lift

$L_2 = 380 - 76.7 = 303.3$ Beam Load

$L_3 = L_2 + W_3 = 303.3 + 31 = 334.3$ Load on Aft Lift Sockets is satisfactory

ALLIANCE ARRANGEMENT

Refer to Sketch D-2

$$L_4 = \frac{29.15\,L_3}{25.57}$$

$L_4 = \dfrac{29.15\,(334.3)}{25.57} = 381.1$ Lift on Aft Pulleys is satisfactory

$CW = 381.1 - 334.3 = 46.8$ Counterweight on Forward Load Frame.

6. ITEM 13d - P & H 6250 TRUCK CRANE ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Refer to Sketch D-1

$X = 31.75$

$W_3 = 31$

$W_2 = 236$

$W_1 = 190$

$L_1 = 76.7$ External Lift Same as Items 11c and 13c Because the Causeway Components are the Same.

$L_2 = 426 - L_1 = 426 - 76.7 = 349.3$ Beam Load

$L_3 = 349.3 + 31 = 380.3$ Load on Aft Lifting Sockets is satisfactory

ALLIANCE ARRANGEMENT

Refer to Sketch D-2

$$L_4 = \frac{29.15\ (380.3)}{25.57} = 433.5$$ Lift on Aft Pulleys is satisfactory

CW = 433.5 - 380.3 = 53.2 Counterweight on the Forward End of the Load Frame

APPENDIX "E"

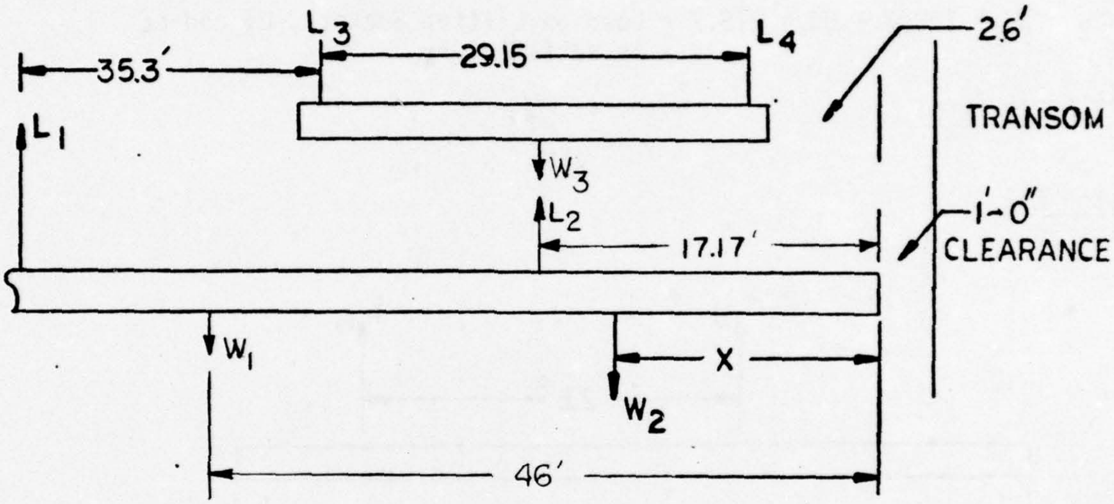
CALCULATIONS FOR USE OF

PEDESTAL CRANE ON LIGHTER CRANE

1. ITEM 11c - BUCYRUS ERIE CRANE MK-100 ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Sketch E-1



X = 31.75 Ft. (Assumed)

$W_1 = 190$

$W_2 = 111$

$W_3 = 60$ (Assumed Weight of Adapter)

L_1 = External Lift

L_2 = Symmetrical Lift by Lighter Crane

ΣV: $L_1 + L_2 - W_1 - W_2 = 0$

$$L_1 + L_2 = W_1 + W_2$$

$$L_1 + L_2 = 190 + 111 = 301$$

$$L_2 = 301 - L_1$$

ΣM: $67.05\ L_1 + 17.17\ L_2 - 46\ W_1 - 31.75\ W_2 = 0$

$$67.05\ L_1 + 17.17\ (301 - L_1) - 46\ (190) - 31.75\ (111) = 0$$

$$67.05\ L_1 + 5168.17 - 17.17\ L_1 - 8740 - 3524.25 = 0$$

$$67.05\ L_1 - 17.17\ L_1 = 8740 + 3524.25 - 5168.17$$

$$49.88\ L_1 = 7096.08$$

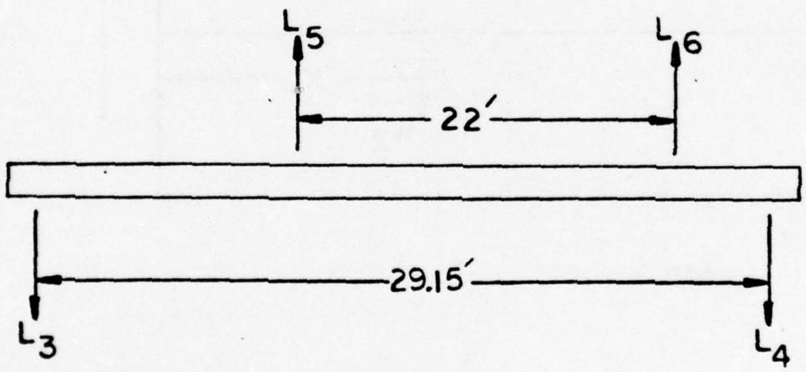
$L_1 = 142.26$ External Lift

$L_2 = 301 - L_1 = 301 - 142.26 = 158.7$ Symmetrical Lift by Lighter Crane

$L_2 + W_3 = 158.7 + 60 = 218.7$ = Load on Lifting Sockets, L_3 and L_4 is satisfactory

ALLIANCE ARRANGEMENT

Sketch E-2



$L_3 + L_4 = 218.7$ Symmetrical Load on Lifting Sockets

$L_5 + L_6 = 218.7$ Symmetrical Lift by Lighter Crane is satisfactory

2. ITEM 12c - P & H 9125 TRUCK CRANE ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Refer to Sketch E-1

$X = 31.75$

$W_1 = 190$

$W_2 = 190$

$W_3 = 60$

L_1 = External Lift

L_2 = Symmetrical Lift by Lighter Crane

$L_1 + L_2 = 190 + 190 = 380$

$L_2 = 380 - L_1$

ΣM: $67.05\ L_1 + 17.17\ (380 - L_1) - 46\ (190) - 31.75\ (190) = 0$

$67.05\ L_1 + 6524.6 - 17.17\ L_1 - 8740 - 6032.5 = 0$

$67.05\ L_1 - 17.17\ L_1 = 8740 + 6032.5 - 6524.6$

$49.88\ L_1 = 8247.9$

$L_1 = 165.4$ External Lift

$L_2 = 380 - 165.4 = 214.6$ Symmetrical Lift by Lighter Crane

$L_3 + L_4 = L_2 + W_3 = 214.6 + 60 = 274.6$ Symmetrical Load on Lifting Sockets is satisfactory

ALLIANCE ARRANGEMENT

Refer to Sketch E-2

$L_5 + L_6 = L_3 + L_4 = 274.6$ Symmetrical Lift on Lighter Crane is satisfactory

3. ITEM 13d - P & H 6250 TRUCK CRANE ON 4 x 15 CAUSEWAY WITH 6 EXTERNAL SPUDWELLS

MORGAN ARRANGEMENT

Refer to Sketch E-1

$X = 31.75$

$W_1 = 190$

$W_2 = 236$

$W_3 = 60$

$L_1 + L_2 = 190 + 236 = 426$

$L_2 = 426 - L_1$

$\lessgtr M$: $67.05\ L_1 + 17.17\ (426 - L_1) - 46\ (190) - 31.75\ (236) = 0$

$67.05\ L_1 + 7314.42 - 17.17\ L_1 - 8740 - 7493 = 0$

$57.05\ L_1 - 17.17\ L_1 = 8740 + 7493 - 7314.42$

$49.88\ L_1 = 8918.58$

$L_1 = 178.8$ External Lift

$L_2 = 426 - 178.8 = 247.2$ Symmetrical Lift by Lighter Crane

$L_3 + L_4 = L_2 + W_3 = 247.2 + 60 = 307.2$ Symmetrical Load on Lifting Sockets is satisfactory

ALLIANCE ARRANGEMENT

Refer to Sketch E-2

$L_5 + L_6 = L_3 + L_4 = 307.2$ Symmetrical Lift by Lighter Crane is satisfactory

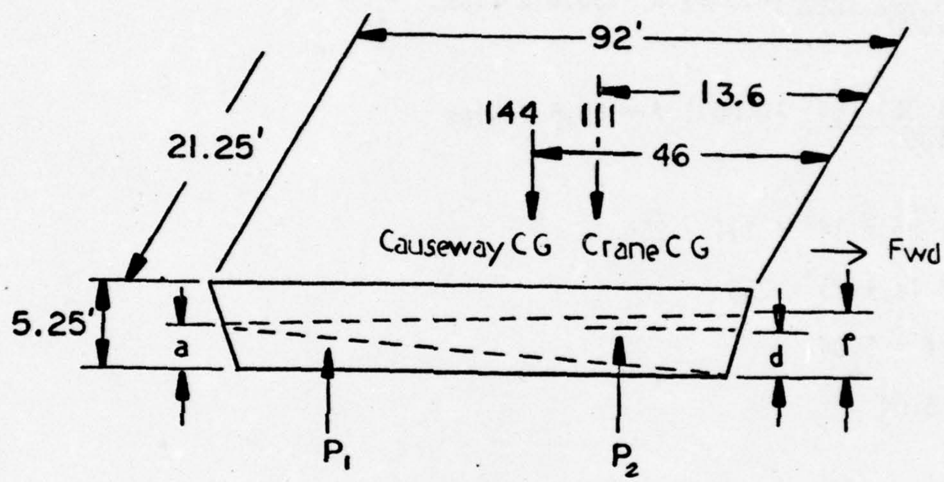
APPENDIX "F"

CALCULATIONS FOR TRIM

AND STABILITY OF OUTSIZE CARGO COMPONENTS

In referring to Table 3.1, Candidate Outside Cargo Components, Item 11b, consisting of the Bucyrus Erie Crane on the 3 x 15 causeway with 6 external spudwells, shall be the first item subject to review.

1. TRIM CALCULATIONS FOR ITEM 11b, BUCYRUS ERIE MK-100 CRANE ON 3 x 15 PONTOON CAUSEWAY



V = Normal displacement of unloaded component

d = Normal draft of unloaded component

P_1 = Buoyancy aft in Kips of loaded component (Acts through centroid of lower triangle in above figure)

P_2 = Buoyancy forward in Kips of loaded component (Acts through centroid of upper triangle in above figure)

a = Draft aft of loaded component

f = Draft forward of loaded component

P1 Pontoon Displacement at 20" Draft = $\frac{60.4\ (84)\ (20)}{1728}$ = 58.7 cu. ft.

P5F and P5M Pontoon Can Displacement at 20" Draft = $\frac{10\ (27.81)\ (84)}{1728}$ = 13.5 cu. ft.

V_1 Actual = 39 (58.7) + 6 (13.5) = 2370.3 cu. ft. based on displacement of pontoons at light draft of 20 inches.

V_2 Apparent = $(78)\ (21.25)\ \frac{(20)}{12} + 2\ (82.04) = 2926.6$ cu. ft. based on overall submerged dimensions.

Correction Factor = $\frac{2370.3}{2926.6} = 0.809$

d = 20 inches (from P-Series Handbook)

$$P_1 = \frac{46\ (21.25)\ (64)}{1000}\ (0.809)\ a = 50.6\ a \text{ Kips}$$

$$P_2 = 46\ \frac{(21.25)\ (64)}{1000}\ (0.809)\ f = 50.6\ f \text{ Kips}$$

ΣV: $P_1 + P_2 = 144 + 111 - 255$

$50.6\ (a + f) = 255$

$a + f = 5.04$

$a = 5.04 - f$

ΣM: $\frac{92}{3} P_1 + 2\ \left(\frac{92}{3}\right) P_2 = 144\ (46) + 78.4\ (111)$

$30.66\ P_1 + 61.33\ P_2 = 6624 + 8702.4$

$30.66\ P_1 + 61.33\ P_2 = 15326.4$

$P_1 = 50.6\ (5.04 - f)$

$P_1 = 255.0 - 50.6\ f$

$P_2 = 50.6\ f$

$30.66\ (255.0 - 50.6\ f) + 61.33\ (50.6\ f) = 15326.4$

$7818.3 - 1551.4\ f + 3103.3\ f = 15326.4$

$3103.3\ f - 1551.4\ f = 15326.4 - 7818.3$

$1551.9\ f = 7508.1$

$f = 4.8$ ft.

$a = 5.04 - 4.8 = 0.24$ ft.

Fwd. Freeboard = 5.25 - 4.8 = 0.45 Ft.

Aft Freeboard = 5.25 - 0.24 = 5.01 Ft.

The trim conditions when the component is loaded with a MK-100 Crane as shown in the above figure is considered unsatisfactory for Sea State 3 conditions.

Reference is made to Item 11b on Page B-7. The following calculations will determine the amount the crane can be moved aft without exceeding the LCM-8 beam load in order to improve trim.

$$L_2 = 416.6 + 31 = 447.6$$

$$L_2 = \frac{\underline{W_4}\ X_4 + 903.65 + X_5\ (111)}{29.15}$$

$$X_5 = \frac{29.15\ (447.6) - 43.4\ (144) - 903.65}{111}$$

$$X_5 = \frac{13047.54 - 6249.6 - 903.65}{111}$$

$$X_5 = 53.10'$$

$$\text{Alliance lift} = \frac{29.15}{25.57}\ (447.6) = 510.2$$

which is the maximum limit of the crane. From the above, it is evident that the crane could be placed at the center of the component if desired for the purpose of improving stability.

Stability calculations will be revised with the crane moved aft so that the center of gravity is at the center of the component.

$$30.66\ P_1 + 61.33\ P_2 = 6624 + 46\ (111)$$

$$30.66\ P_1 + 61.33\ P_2 = 6624 + 5106$$

$$30.66\ P_1 + 61.33\ P_2 = 11730$$

$3103.3\ f - 1551.4\ f = 11730 - 7818.3$

$1551.9\ f = 3911.7$

$f = 2.59$

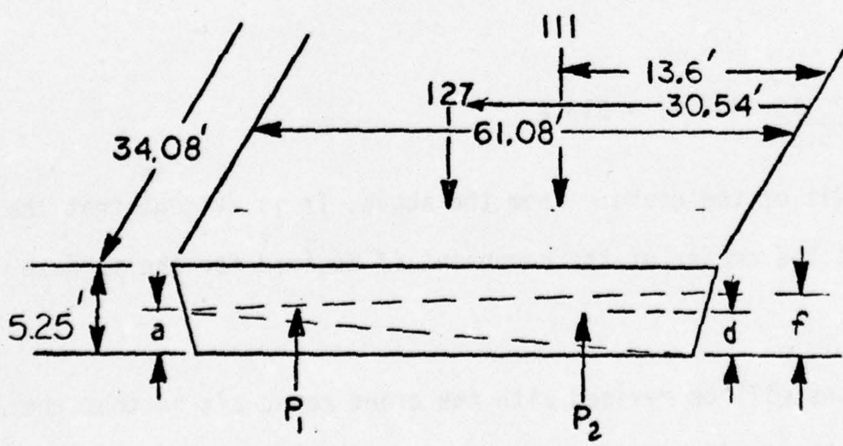
$a = 5.18 - f$

$a = 5.18 - 2.59 = 2.59$

Based on the revised calculations above, the freeboard forward and aft is 5.25 - 2.59 or 2.66 feet.

Stability calculations will not be completed for the 4 x 15 causeway and the AMMI causeway because they have greater load capacity than the 3 x 15 causeway component. Calculations for the smaller 4 x 10 causeway component will be completed.

2. TRIM CALCULATIONS FOR ITEM 11d, THE BUCYRUS ERIE MK-100 CRANE ON THE 4 x 10 CAUSEWAY



V = Normal displacement of unloaded component

d = Normal draft of unloaded component

P_1 = Buoyancy aft in Kips of loaded component

P_2 = Buoyancy forward in Kips of loaded component

a = Draft aft of loaded component

f = Draft forward of loaded component

$$V = \frac{127000 \text{ lbs.}}{64 \text{ lb/ft}^3} = 1984.37 \text{ cu. ft.}$$

Correction Factor = 0.809

$$d = \frac{1984.37 \text{ cu. ft.}}{61.08\ (34.08) \text{ ft}^2\ (.809)} = 1.18 \text{ feet}$$

$$P_1 = \frac{61.08\ (34.08)\ (64)\ (.809)\ a}{2\ (1000)} = 53.88 \text{ a Kips}$$

$$P_2 = \frac{61.08\ (34.08)\ (64)\ (.809)\ f}{2\ (1000)} = 53.88 \text{ f Kips}$$

$\leq$ V: $P_1 + P_2 = 127 + 111 = 238$

$53.88\ (a + f) = 238$

$a + f = 4.42$

$a = 4.42 - f$

$\leq$ M: $\frac{61.08}{3} P_1 + \frac{2}{3} (61.08) P_2 = 127\ (30.54) + 47.48\ (111)$

$20.36\ P_1 + 40.72\ P_2 = 3878.58 + 5270.28$

$20.36\ P_1 + 40.72\ P_2 = 9148.86$

$P_1 = 53.88\ (4.42 - f)$

$P_2 = 238.15 - 53.88\ f$

$P_2 = 53.88\ f$

$20.36\ (238.15 - 53.88\ f\ ) + 40.72\ (53.88\ f) = 9148.86$

$4848.73 - 1097.00\ f + 2194.00\ f = 9148.86$

$2194.00\ f - 1097.00\ f = 9148.86 - 4848.73$

$1097.00\ f = 4300.13$

$f = 3.92$

$a = 4.42 - f = 4.42 - 3.92 = 0.50$

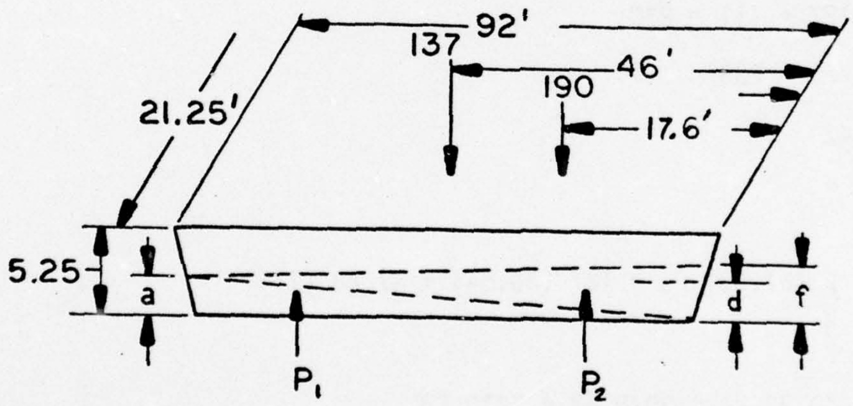
Freeboard Fwd. = 5.25 - 3.92 = 1.33 Ft.

Freeboard Aft = 5.25 - 0.5 = 4.75 Ft.

Under loaded conditions, the causeway will have satisfactory trim conditions.

3. TRIM CALCULATIONS FOR ITEM 12b, P & H 9125 TRUCK CRANE ON 3 x 15 STANDARD CAUSEWAY

Calculations for the P & H 9125 Truck Crane shall first be conducted for the smallest component, namely, the standard 3 x 15 causeway.



V = Normal displacement of unloaded component

d = Normal draft of unloaded component

P_1 = Buoyancy aft in Kips of loaded component

P_2 = Buoyancy forward in Kips of loaded component

a = Draft aft of loaded component

f = Draft forward of loaded component

V = 2370.3 cu. ft. (From Paragraph 1)

d = 20 inches (From P-Series Manual)

Correction Factor = 0.809 (From Paragraph 1)

$$P_1 = \frac{(92)\ (21.25)\ (64)\ (0.809)\ a}{2000} = 50.6\ a \text{ Kips}$$

$$P_2 = \frac{92\ (21.25)\ (64)\ (0.809)\ f}{2000} = 50.6\ f \text{ Kips}$$

$$\Sigma V: \quad P_1 + P_2 = 137 + 190$$

$$P_1 + P_2 = 327$$

$$50.6\ (a + f) = 327$$

$$a + f = 6.46$$

$$a = 6.46 - f$$

$$\Sigma M: \quad \frac{92}{3} P_1 + \frac{2}{3} (92)\ P_2 = (137)\ 46 + 74.4\ (190)$$

$$30.66\ P_1 + 61.33\ P_2 = 6302 + 14136$$

$$30.66\ P_1 + 61.33\ P_2 = 20438$$

$$P_1 = 50.6\ (6.46 - f)$$

$$P_1 = 326.87 - 50.6\ f$$

$$P_2 = 50.6\ f$$

$$30.66\ (326.87 - 50.6\ f) + 61.33\ (50.6)\ f = 20438$$

$$10021.83 - 1551.39\ f + 3103.30\ f = 20438$$

$$3103.30\ f - 1551.39\ f = 20438 - 10021.83$$

$$1551.91\ f = 10416.17$$

$$f = 6.71 \text{ feet}$$

$$a = 6.46 - 6.71 = -0.25$$

Freeboard Fwd. = 5.25 - 6.71 = -1.46 Ft.

Freeboard Aft = 5.25 - (-0.25) = 5.50 Ft.

Although it is possible to complete the above lift as configured using both Alliance and Morgan Cranes, it is an impractical solution because of the trim involved. It is evident from the above calculations that the forward end of the component would be awash by about 1.46 feet and the after end would be out of the water by 0.25 feet.

Reference is made to Item 12b on Page B-8. The following calculations will determine the distance the crane can be moved aft without exceeding the beam load limit.

$$L_2 = 416.6 + 31 = 447.6$$

$$L_2 = \frac{W_4 X_4 + 903.65 + X_5 W_5}{29.15}$$

$$X_5 = \frac{29.15 (447.6) - 43.4 (137) - 903.65}{190}$$

$$X_5 = \frac{13047.54 - 5945.8 - 903.65}{190}$$

$$X_5 = 32.62$$

$$\text{Alliance lift} = \frac{29.15}{25.57} (447.6) = 510.2 \text{ which is maximum}$$

It is possible to move the crane 17.62 feet farther aft without exceeding the capabilities of either crane.

Revisions to trim conditions based on the new crane position are as follows:

$$30.66 P_1 + 61.33 P_2 = 6302 + 56.8 (190)$$

$30.66\ P_1 + 61.33\ P_2 = 6302 + 10792 = 17094$

$3103.30\ f - 1551.39\ f = 17094 - 10021.83$

$1551.91\ f = 7072.17$

$f = 4.56$ feet

$a = 6.46 - f$

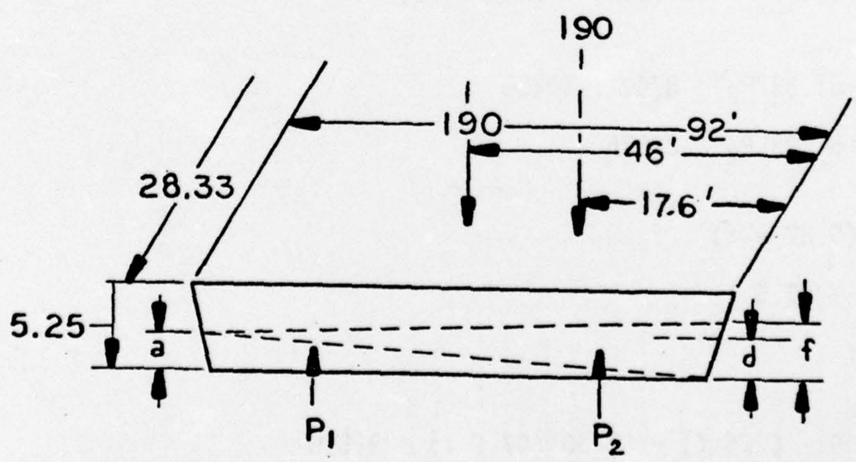
$a = 6.46 - 4.56 = 1.90$

Freeboard Fwd. = 5.25 - 4.56 = 0.69 Ft.

Freeboard Aft = 5.25 - 1.90 = 3.35 Ft.

Based on the above calculations, the outsize cargo component consisting of 3 x 15 standard causeway with P & H 9125 Truck Crane when loaded, would have 0.69 feet freeboard forward and 3.35 feet freeboard aft when loaded under the most favorable conditions, using the LCM-8 lifting beam and appropriate counterweights.

4. TRIM CALCULATIONS FOR ITEM 12c - P & H 9125 TRUCK CRANE ON 4 x 15 CAUSEWAY W/6 EXTERNAL SPUDWELLS



P1 Pontoon Displacement = 58.7 cu. ft.

P5F and P5M Displacement = 13.5 cu. ft.

V_1 Actual Displacement = 52 (58.7) + 8 (13.5) = 3160.4

V_2 Apparent Displacement = $(78)\ (28.3)\ \left(\frac{20}{12}\right) + 2\ (109.4)$

$V_2 = 3679 + 218.8 = 3897.8$

Correction Factor = $\frac{3160.4}{3897.8} = 0.811$

$$P_1 = \frac{(92)\ (28.33)\ (64)\ (0.811)\ a}{2000} = 67.6\ a \text{ Kips}$$

$$P_2 = \frac{(92)\ (28.33)\ (64)\ (0.788)\ f}{2000} = 67.6\ f \text{ Kips}$$

ΣV: $P_1 + P_2 = 190 + 190 = 380$

$67.6\ (a + f) = 380$

$a + f = 5.62$

$a = 5.62 - f$

ΣM: $\frac{92}{3} P_1 + \frac{2}{3} (92)\ P_2 = 46\ (190) + 74.4\ (190)$

$30.66\ P_1 + 61.33\ P_2 = 8740 + 14136$

$30.66\ P_1 + 61.33\ P_2 = 22876$

$P_1 = 67.6\ (5.62 - f)$

$P_1 = 379.9 - 67.6\ f$

$P_2 = 67.6\ f$

$30.66\ (379.9 - 67.6\ f) + 61.33\ (67.6\ f) = 22876$

$11647.7 - 2072.6\ f + 4145.9\ f = 22876$

$4145.9\ f - 2072.6\ f = 22876 - 11647.7$

$2073.3\ f = 11228.3$

$f = 5.42$ feet

$a = 5.62 - 5.42 = 0.20$ feet

Freeboard Fwd. = 5.25 - 5.42 = -0.17 Ft.

Freeboard Aft = 5.25 - 0.20 = 5.05 Ft.

Based on the above calculations, the loaded 4 x 15 causeway is awash forward by 0.17 feet and aft the freeboard is 5.05 feet.

By referring to Item 12c on Page B-9, the calculations will be reviewed to determine the distance the crane can be moved aft in order to improve trim conditions.

$$L_2 = 416.6 + 31 = 447.7$$

$$L_2 = \frac{W_4 X_4 + 903.65 + X_5 W_5}{29.15}$$

$$X_5 = \frac{29.15 (447.7) - 43.4 (190) - 903.65}{190}$$

$$X_5 = \frac{13047.54 - 8246 - 903.65}{190}$$

$$X_5 = 20.51 \text{ feet}$$

$$\text{Alliance lift} = \frac{29.15}{25.57} (447.6) = 510.3 \text{ which is crane maximum}$$

Revised trim calculations based on the new crane position are as follows:

$$30.66 P_1 + 61.33 P_2 = 8740 + 68.9 (190)$$

$$30.66 P_1 + 61.33 P_2 = 8740 + 13091$$

$$30.66 P_1 + 61.33 P_2 = 21831$$

$$4145.9 f - 2072.6 f = 21831 - 11647.7$$

$$2073.3 f = 10183.3$$

$f = 4.91$

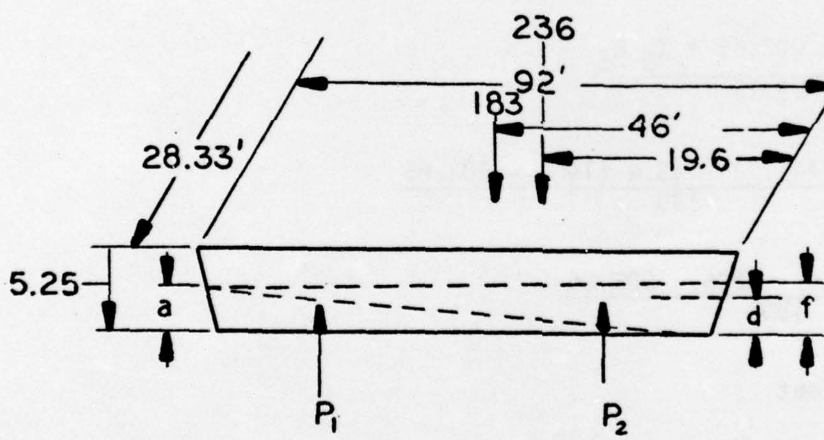
$a = 5.62 - 4.91 = 0.71$

Freeboard Fwd. = 5.25 - 4.91 = 0.34 Ft.

Freeboard Aft = 5.25 - 0.71 = 4.54 Ft.

Based on the above calculations resultant trim considering the most favorable lifting conditions using LCM-8 counterweight technique, the freeboard forward is 0.34 feet and 4.54 feet aft. Further trim improvement would require another lifting technique.

5. TRIM CALCULATIONS FOR ITEM 13c - P & H 6250 TRUCK CRANE ON 4 x 15 CAUSEWAY



From Paragraph 4.

$P_1 = 67.6\ a$ Kips

$P_2 = 67.6\ f$ Kips

$\sum V$: $P_1 + P_2 = 183 + 236 = 419$

$67.6\ (a + f) = 419$

$a + f = 6.20$

$a = 6.20 - f$

$$\Sigma M: \frac{92}{3} P_1 + \frac{2}{3} (92) P_2 = 46 (183) + 72.4 (236)$$

$$30.66 P_1 + 61.33 P_2 = 8418 + 17086.4$$

$$30.66 P_1 + 61.33 P_2 = 25504.4$$

$$P_1 = 67.6 (6.20 - f)$$

$$P_1 = 419.12 - 67.6 f$$

$$P_2 = 67.6 f$$

$$30.66 (419.12 - 67.6 f) + 61.33 (67.6 f) = 25504.4$$

$$12850.22 - 2072.62 f + 4145.91 f = 25504.4$$

$$4145.91 f - 2072.62 f = 25504.4 - 12850.22$$

$$2073.29 f = 12654.18$$

$$f = 6.10$$

$$a = 6.20 - 6.10 = 0.10$$

Freeboard Fwd. = 5.25 - 6.10 = -0.85 Ft.

Freeboard Aft = 5.25 - 0.10 = 5.15 Ft.

Since the bow would end up underwater, the crane will be moved aft to correct trim.

Referring to Item 13c on Page B-10, the lift will be recalculated to determine the distance that the crane can be moved aft.

$$L_2 = 416.6 + 31 = 447.7$$

$$L_2 = \frac{W_4 X_4 + 903.65 + X_5 W_5}{29.15}$$

$$X_5 = \frac{29.15 (447.7) - 43.4 (183) - 903.65}{236}$$

$X_5 = 17.80$

The maximum additional distance that we can move the crane aft is only 0.8 feet which would be insignificant in changing the stability.

6. <u>TRIM CALCULATIONS FOR ITEM 13c - P & H 6250 TRUCK CRANE ON AMMI CAUSEWAY</u>

Length = 90'

Width = 28'

Height = 5'

Normal Draft = 8'

C.G. of Crane 17 Feet from Fwd. End of AMMI Causeway

$$P_1 = \frac{28\ (45)\ (64)\ a}{1000} = 80.6\ a \text{ Kips}$$

$$P_2 = \frac{28\ (45)\ (64)\ f}{1000} = 80.6\ f \text{ Kips}$$

$$P_1 + P_2 = 110 + 236 = 346$$

$$\frac{90}{3} P_1 + 2 \left(\frac{90}{3}\right) P_2 = 110\ (45) + 236\ (73)$$

$$30\ P_1 + 60\ P_2 = 4950 + 17228$$

$$30\ P_1 + 60\ P_2 = 22178$$

$$80.6\ (a + f) = 346$$

$$a + f = \frac{346}{80.6} = 4.3$$

$$a = 4.3 - f$$

$$P_1 = 80.6\ (4.3 - f)$$

$$P_1 = 34.6 - 80.6\ f$$

$$P_2 = 80.6\ f$$

$30\ (346.6 - 80.6\ f) + 60\ (80.6)\ f = 22178$

$10398 - 2418\ f + 4836\ f = 22178$

$2418\ f = 22178 - 10398$

$2418\ f = 11780$

$f = 4.9$

$a = 4.3 - 4.9 = -0.6$

Freeboard Fwd. = 5.0' - 4.9' = 0.1'

Freeboard Aft = 5 - (-0.6) = 5.6'

Based on the above calculations, the freeboard of the loaded AMMI Causeway would be 0.1 feet forward and 0.6' out of the water aft.

The trim can be corrected by moving the center of gravity of truck crane aft consistent with maximum load on the LCM-8 beam.

L_2 = 447.6 - Maximum LCM-8 Beam Load plus Weight of Beam.

Refer to Item 13c on Page B-11.

$$X_5 = \frac{29.15\ (447.6) - 110\ (43.4) - 903.65}{236}$$

$$X_5 = \frac{13047.54 - 4774 - 903.65}{236}$$

$$X_5 = \frac{7369.89}{236} = 31.22$$

Revised trim calculations based on moving the truck center of gravity to a point 31.2 feet aft of the forward end of the causeway:

$30\ P_1 + 60\ P_2 = 110\ (45) + 236\ (58.8)$

$30\ P_1 + 60\ P_2 = 4950 + 13876$

$30\ P_1 + 60\ P_2 = 18827$

$2418\ f = 18827 - 10398$

$2418\ f = 8428.8$

$f = \dfrac{8428.8}{2418} = 3.5'$

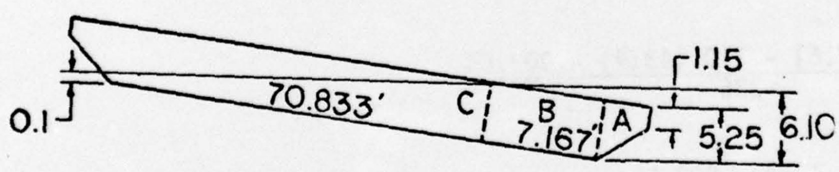
$a = 4.3 - 3.5 = 0.8$

Freeboard Fwd. = 5.0 - 3.5 = 1.5'

Freeboard Aft = 5.0 - 0.8 = 4.2'

By changing the position of the center of gravity farther aft, the stern is no longer out of the water. Corrected freeboard will be 1.5 feet forward and 4.2 feet aft.

7. TRANSVERSE STABILITY CALCULATIONS FOR ITEM 13c - P & H 6250 TRUCK CRANE ON 4 x 15 CAUSEWAY



A = 22.4 ft^2 with centroid at 3.431'

B = 37.627 ft^2 with centroid at 2.625'

C = 179.562 ft^2 with centroid at 1.75'

$$KB = \frac{22.4 \times 3.431 + 37.627 \times 2.625 + 179.562 \times 1.75}{239.589}$$

$$= \frac{76.854 + 98.771 + 314.23}{239.589} = 2.044$$

Volume of displacement = 239.589 x 28.3 = 6780.368 cubic feet

$$I = \frac{bh^3}{12}$$

$$= \frac{92 \times (28.3)^3}{12}$$

$$= 173{,}766.43$$

$$BM = \frac{I}{\triangle}$$

$$= \frac{173{,}766.43}{6780.368}$$

$$= 25.628 \text{ feet}$$

CG of barge = 2.7' above keel

CG of crane = 8.75' above crane base line (approximate)

$$KG = \frac{183 \times 2.7 + 236 \times (5.25 + 8.75)}{419}$$

$$= \frac{494.1 + 3304}{419} = \frac{3798.1}{419}$$

$$= 9.065'$$

$$GM = KB + BM - KG$$

$$GM = 2.044 + 25.628 - 9.065$$

$$GM = 18.607 \text{ feet}$$

Since the GM is a positive 18.607 ft. the causeway has positive transverse stability which is satisfactory.

8. LONGITUDINAL STABILITY CALCULATIONS FOR ITEM 13c - P & H 6250 TRUCK CRANE ON 4 x 15 CAUSEWAY

From Paragraph 7:

Volume of Displacement = 6780.368 cu. ft.

$$KB = 2.044$$

$$KG = 9.065$$

$$I = \frac{h\ b^3}{12}$$

$$I = \frac{28.3\ (92)^3}{12}$$

$$I = 1836405.7$$

$$BM = \frac{I}{\triangle} = \frac{1836405.7}{6780.368} = 270.841$$

$$GM = KB + BM - KG$$

$$GM = 2.044 + 270.841 - 9.065$$

$$GM = 263.82$$

Normally, ships are considered longitudinally stable if the longitudinal GM is of the same magnitude as the ship's length. Since the longitudinal GM of the loaded causeway component is 2.89 times its length, it is considered quite satisfactory.

LIST OF REFERENCES

1. Merchant Ship Expeditionary Logistic Facility dated October 1973.

2. Capability Study for Barge Ships in Direct Fleet Support dated April 1973.

3. Pontoon Gear Handbook Navy Lightered (N.L.) Equipment P-Series dated November 1974.

4. AMMI Pontoon - A Naval Facilities Engineering Command - SeaBee Development.

5. Morgan Engineering Co. Drawing No. D-371773 Lifting Beam for LCM-8 Landing Craft.

6. Morgan Engineering Co. Drawing No. D-369030 510 Ton LASH Crane Clearance and General Arrangement.

7. Morgan Engineering Co. Drawing No. D-371844 Clearance Drawing for LCM-8 Landing Craft Lifting Beam.

8. The Alliance Machine Co. Drawing No. 6841B1 500 Ton LASH Gantry Crane - General Assembly of Gantry.

9. The Alliance Machine Co. Drawing No. 684141 500 Ton LASH Gantry Crane - General Assembly of Lifting Beam.

10. MARAD Plan Lists for C-8 and C-9 LASH Ships.

11. Dwg. #228-S16-2-3 - Hatch Cover Details.

12. Dwg. #228-S12-6-1 - General Arrangement - Outboard Profile.

13. Dwg. #228-S12-7-1 - General Arrangement - Inboard Profile.

14. Dwg. #228-S33-1-12 - General Arrangement - Main Deck Aft.

LIST OF REFERENCES (Continued)

15. Dwg. #228-S9-0-1 - Booklet of General Plans - Inboard and Outboard Profiles.

16. Dwg. #228-S9-0-1 - Booklet of General Plans - Main and 2nd Deck.

17. Dwg. #228-S29-1-1 - Capacity Plan.

18. Dwg. #228-S29-1-7 - Stability Booklet.

19. Dwg. #228-S61-0-1 - Generator Load Analysis.

20. Dwg. #228-S-12-6-1B (PG) - General Arrangement - Outboard Profile.

21. Dwg. #228-S12-6-1A (PFEL) - General Arrangement - Outboard Profile.

22. Dwg. #259-S61-0-1 - Generator Load Analysis.

23. Dwg. #259-S11-5-7 - W. T. Longitudinal Bhds. 35' and 40' Off Centerline Aft.

24. Dwg. #259-S1 -6-5 - Craneway Extension.

25. Dwg. #259-S11-11-1 - Midship Section.

26. Dwg. #259-S17-1-1 - Sheets 1 & 2 - Gantry Crane Installation Details.

27. Dwg. #259-S12-6-1 - General Arrangement - Outboard Profile.

28. Dwg. #265-S12-6-1 - General Arrangement - Outboard Profile.

29. Dwg. #262-S12-6-1 - General Arrangement - Outboard Profile.

30. Dwg. #265-S12-7-1 - General Arrangement - Inboard Profile.

LIST OF REFERENCES (Continued)

31. Dwg. #259-S12-7-1 - General Arrangement - Inboard Profile.

32. Dwg. #262-S12-7-1 - General Arrangement - Inboard Profile.

33. Dwg. #259-S33-1-12 - General Arrangement - Main Deck Aft.

34. Dwg. #262-S33-1-12 - General Arrangement - Main Deck Aft.

35. Dwg. #265-S33-1-12 - General Arrangement - Main Deck Aft.

36. Dwg. #265-S9-0-1 - Booklet of General Plans - Inboard and Outboard Profiles.

37. Dwg. #259-S9-0-1 - Booklet of General Plans - Inboard and Outboard Profiles.

38. Dwg. #262-S9-0-1 - Booklet of General Plans - Inboard and Outboard Profiles.

39. Dwg. #259-S9-0-1 - Booklet of General Plans - Main Deck, 2nd Deck & Misc. Flats.

40. Dwg. #265-S9-0-1 - Booklet of General Plans - Main Deck, 2nd Deck & Misc. Flats.

41. Dwg. #262-S9-0-1 - Booklet of General Plans - Main Deck, 2nd Deck & Misc. Flats.

42. Dwg. #259-S29-1-1 - Capacity Plan.

43. Dwg. #262-S29-1-1 - Capacity Plan.

44. Dwg. #259-S29-1-2 - Cross Curves of Stability.

45. Dwg. #262-S61-0-1 - Generator Load Analysis.

LIST OF REFERENCES (Continued)

46. Dwg. #265-S61-0-1 - Generator Load Analysis.

47. Dwg. #259-S29-1-2 - Cross Curves of Stability.

48. Dwg. #259-S29-1-7 - Stability Booklet.

49. Dwg. #262-S29-1-7 - Stability Booklet.